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NOTES OF THE LIFE HISTORY OF ROCKY MOUNTAIN BIGHORN SHEEP IN THE TARRYALL MOUNTAINS OF COLORADO

BY CLIFFORD C. SPENCER

The Tarryall mountain range extends for some 15 miles between the north and south forks of the South Platte River, 50 miles northwest of Pikes Peak, on the Pike National Forest in Colorado. The topography varies from meadow lands in the Tarryall Valley to the roughest and wildest areas found on the Pike National Forest. The range is of granitic and basaltic origin, with elevations from 8,600 to more than 12,000 feet. Large areas burned over some 75 years ago are now revegetated with aspen, shrubs, grasses, and forbs. The main winter ranges are on south exposures where the principle type is an open stand of ponderosa and bristlecone pines, and associated species. Alpine meadow types are found on the higher ranges, especially above timberline.

These mountains once supported an outstanding herd of Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*). Severe losses of bighorns experienced in 1885 were believed to have been caused by the psoroptic mite. In 1923–24, the herd was almost destroyed by what appeared to be an epidemic of hemorrhagic septicemia. A census shortly after the epidemic showed that only a few individuals had survived.

An administrative study, designed to gather factual data on the Tarryall bighorns, was started in 1937 and carried on rather intensively in 1940. Data collected included studies on seasonal ranges, migrations, breeding habits, sex-age ratios and census, lambing habits, food preferences, predation, parasites and disease, range conditions, and conflicts.

Credit and thanks for their cooperation during the course of this study are gratefully extended to the following men: Mr. Herbert Wallace of the Colorado Federal Aid in Wildlife Restoration staff, who assisted in the 1940 census; Mr. Charles C. Sperry of the Food Habits Section, Wildlife Research Laboratory of the U. S. Fish and Wildlife Service, at Denver, Colorado, who made scat and pellet examinations; Dr. F. X. Gassner of the Colorado State College, Fort Collins, Colorado, who made the determinations of parasites; Mr. Ralph H. Imler of the Food Habits Section, Wildlife Research Laboratory of the U. S. Fish and Wildlife Service, Denver, Colorado, who analyzed bighorn sheep stomach contents; Dr. H. L. Shantz, Chief of the Division of Wildlife, U. S.

Forest Service, Washington, D. C., and Lloyd W. Swift, Wildlife Division, U. S. Forest Service, Denver, Colorado, under whose direction the studies were planned and carried out and the manuscript prepared; Mr. O. J. Murie, U. S. Fish & Wildlife Service, Jackson, Wyoming, Mr. Raymond Gregg, Naturalist, U. S. National Park Service, Estes Park, Colorado, and Mr. James R. Simon, Wyoming Fish and Game Department, Cheyenne, Wyoming, who reviewed the manuscript and offered valuable suggestions and comments.

It is the purpose of this paper to summarize some of the observations obtained during the study.

SEASONAL RANGES

One-third of the Tarryall sheep remain at or above timberline yearlong, except for a short period when heavy spring snows force them into the aspen type just below timberline. The rest of the herd spends the summer in the high country but migrates to lower elevations for the balance of the year. It was found that regardless of weather conditions, these migrations, which are but a few miles in extent, take place about the same time each year and over the same routes.

Ewes and lambs in small numbers and a few of the younger rams make their appearance on the lower Tarryall ranges in October. Chronological observations show that the number of sheep gradually increases until the height of the breeding season is reached in November. As the breeding season progresses, the ewes and lambs congregate in larger groups. During early December, 105 sheep have been counted in one band. In January, there is a tendency for the larger groups to disband and scatter. The old rams go off by themselves and are seldom found with the ewes and lambs until the next fall.

The older ewes are the first to leave the winter range. The migration to higher ranges starts in April and by May 15 most of the ewes will be found on or near the areas used as lambing grounds. The rams and young sheep may not go to the high country until June. As many as 45 rams were observed in one bunch on the summer range.

BREEDING HABITS

The rams were ready for the rut before the ewes and were seen bothering them early in November. This was especially true of the younger rams, which were more aggressive than the older ones. The first actual breeding was observed on November 15. For several days prior to breeding, the rams were restless and were observed milling around, striking, batting and even riding one another. They were constantly following and chasing the unreceptive ewes.

The younger ewes were the first to be ready for the rut. They were promptly cut out of the herd and at times chased over the mountain sides by the rams. The fact that seldom more than one or two ewes seemed to be in oestrus at the same time gave the rams a chance to move from bunch to bunch in pursuit of the receptive ewes. A chase, starting with one ewe and one ram, often ended with as many as eleven rams in pursuit.

After the rutting season once opened, the older and larger rams were the most aggressive and assumed the most important part in the mating activities. The

younger rams take part and should not be overlooked, but they cannot compete with the big fellows, except in a foot race. During some of the long chases over the rim rocks and steep slopes, the younger rams were observed several times to have more speed and endurance and, on other occasions, it was noted that they even outguessed the older rams and exercised strategy to overcome their handicaps in size.

Ewes, attempting to escape the attention of the rams or to rest during the chases and battles, crawl into crevices or under overhanging rocks or out on narrow ledges, and lie down. The minute they get to their feet, the chase is resumed.

Service requires but several seconds. Most, and perhaps all, ewes are bred many times during the receptive period, not only by different rams, but quite often several times by the same ram within a very few minutes. With a five-week season and a sex ratio of almost one to one, there is little chance for any mature ewe to go through the season unbred.

The height of the breeding season was November 20–30. After December 1, breeding activity gradually tapered off, and the last breeding observed was on December 19. During the last two weeks, there were not so many battles, and the older ewes did not run so hard, nor so far, as the younger ewes did early in the season.

Ewes become mature at two and one-half years, and give birth to their first lambs at three years of age. Rams under three years of age appeared to take very little, if any, active part in breeding activities.

The bighorn ram does not assemble and guard a harem, but moves from flock to flock during the breeding season. Old rams were observed to point their noses into the air, sniff the breezes for a while, deliberately start out across the hills and go to other flocks. In common with other ungulates, the bighorn ram frequently curls the upper lip, extends the neck and tilts the nose in the air.

FIGHTING

The bighorn ram enjoys a fight, is one of the most passionate big-game species, and is promiscuous in its breeding habits. These traits and a high ratio of males, are responsible for many battles in the Tarryall herd. Those observed were of several kinds.

"Playful" bouts between two rams were noted at various seasons, especially in spring and summer. The main difference between these and similar fights during the rutting season seemed to be that one ram would not take an unfair advantage if his opponent happened to be off balance or not prepared to charge.

Most individual battles in the fall or rut follow a rather definite routine, but anything may happen, and at times nothing is barred. The two rams stand side by side, facing in opposite directions, at times each ram's head over the other's back. Grunting and snorting, while punishing each other by sharp upward blows with the forelegs, the two rams may mill around in this manner from a few seconds to as long as twenty minutes. Following this, they walk away from each other—from 20 to 60 feet—whirl and charge with great speed.

Part of the time, instead of completing the charge on all four feet, they come

up on their hind-feet and cover the last few yards in that manner, with forelegs rigidly extended, and at times the heads turned to one side. Just before the impact, the heads are lowered and they attempt to meet squarely, horn to horn.

The impact, after these charges, is terrific and may be heard for a mile. After the rebound, the two rams may stand, partially dazed, with noses a short distance apart, eyes glassy, and sides heaving for perhaps 20 seconds. Carefully and slowly they back away, stiff-legged, each ram watching the other to see that no unfair advantage is taken. After this short "time out," they get set and repeat the performance. Some of these battles last more than two hours. Quite often, it is impossible to determine which ram is the winner. The battle may end as suddenly as it began, and the rams may walk away in a seemingly friendly fashion.

Knockdowns during individual fights were few—two having been seen. Several times, rams failed to meet squarely, horn to horn, and once a ram slid under his opponent.

"Battles royal" occur during the mating season. They are genuine free-for-alls in which nothing is barred, include no fixed or regular routine, are far more furious and exciting than individual fights, may last for an entire day, and in which as many as 14 rams have been observed at one time. The ewes responsible for most of these battles were not always able to keep out of the way, and at times received rough treatment.

One "battle royal" observed started with four rams in a "huddle" after the manner of football players, with heads together and noses close to the ground. The break from this was sudden and the fight that followed was carried on at a terrific pace for at least 20 minutes. At that time, one ram and then a second backed away from the battle and retired into the rim rocks. The other two continued fighting until tired, rested a short time, then resumed the fight. The ewes became frightened because of my presence, and the battle was temporarily postponed. Many other battles were observed. One day, three battles were watched from one place at the same time, a "battle royal" between 14 rams, and two individual battles.

LAMBING SEASON

The gestation period for bighorn sheep was found to be approximately 180 days. The first lambs were born on May 16 and the season was nearly over by June 15. Twin lambs were not observed.

Ewes went into solitary confinement in the wildest and most inacessible areas they could find, and for several days stayed in very small areas—sometimes without food or water. As the lambs grew strong enough to follow, the ewes formed groups again, always staying near the roughest rim rocks in the area. In August, as many as 60 in a group were observed near or above timberline.

The lambs are weak and helpless at first but develop rapidly and after one week are perfectly at home on the granite rocks, where they play in a daring and reckless manner. They follow the ewes and are not cached away like fawns. Newborn lambs are small and easily walk under the ewes. They reach up to

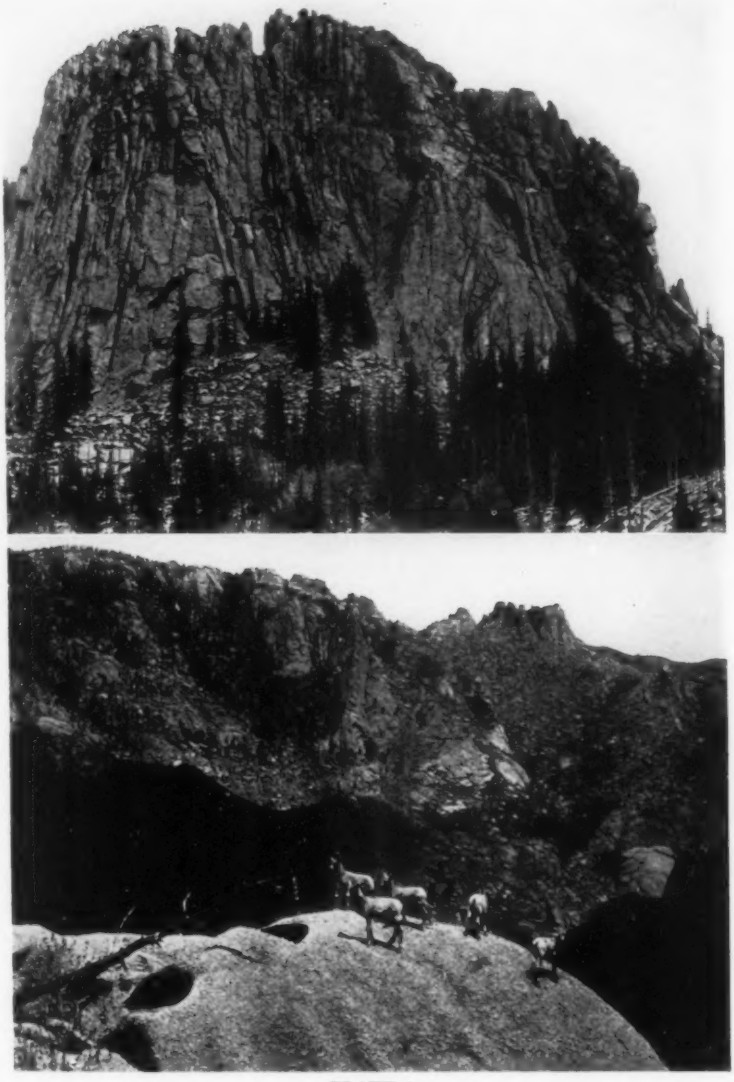

PLATE 1

Upper: Teakettle Rock—"Maternity Ward and Nursery" for bighorn lambs.
Lower: Bighorn lambs, three weeks old, at play in rough back country of the Tarryall Mountains.

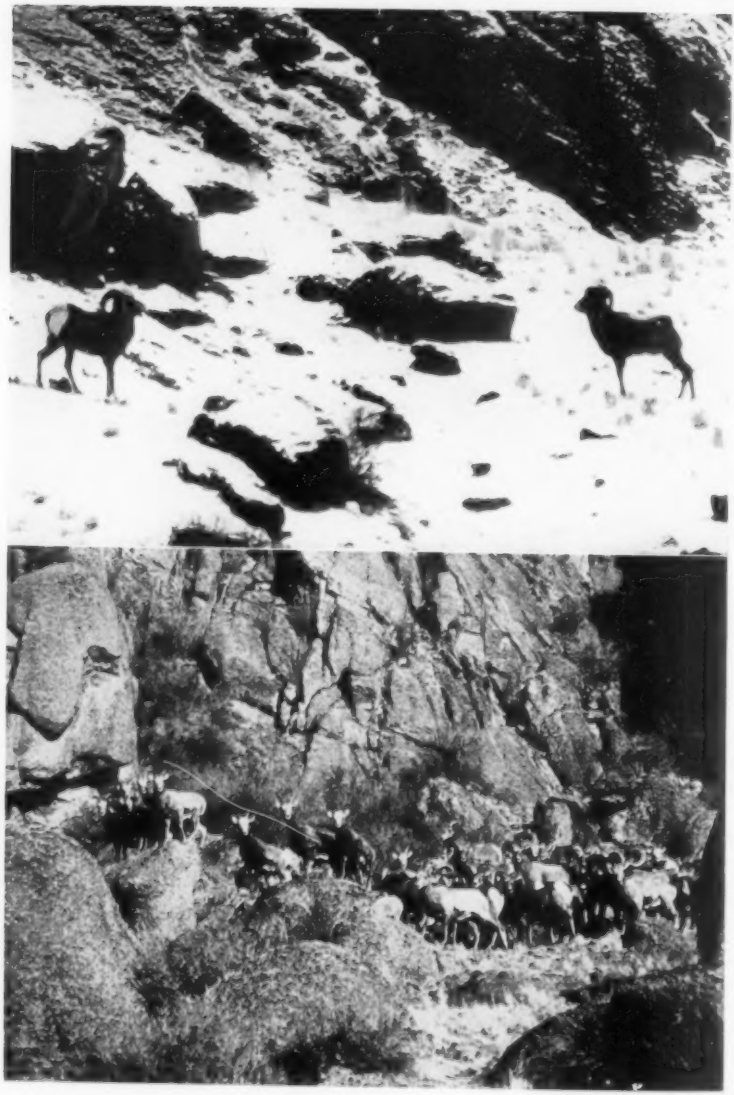

PLATE 2

Upper: Battling rams ready for a charge.
Lower: Bighorn sheep on winter range in the Tarryall Mountains.

feed and brace themselves, sometimes with a front foot, against the ewe's hind-leg. When they are a month old they have grown so that they get down on their knees to nurse.

Feeding periods are rather frequent and last from one and one-half to three minutes at first. Later, they are less frequent, and lambs are seldom permitted to nurse for more than twenty seconds. The lambs were seen nibbling grass and clover at an early age, and by the end of the first month, grazed right along with the ewes.

Weaning starts early in the fall. The ewes apparently permit a certain amount of nursing in October because their udders are still somewhat enlarged in November. Even so, no nursing was observed during October, November, or December, although the lambs were seen to try many times without success.

The ewes were naturally very alert during the lambing period and while the lambs were young. At least two ewes stood guard during feeding and resting periods and, because of the topography of the areas chosen for lambing grounds and nurseries, it was almost impossible to approach them without being detected.

Lambs stay close together when playing and when bedded down. As many as nine lambs have been seen following one amiable old ewe which acts as a "nursemaid" while other ewes wander off a short distance to feed. This also may occur when they have been frightened and separated. The young lambs are genuine comedians and seemingly take delight in exciting the ewes unnecessarily by sounding false alarms. Curious two-year-olds and yearlings attempting to play with the young lambs were often severely chastised by the mothers.

VOICE

The voice of the bighorn is similar to that of domestic sheep. Many times during the summer, bands were easily located in rough canyons by the blatting of the ewes and lambs, which could be heard for considerable distances. They were seldom heard after August, and then generally when lambs became separated from ewes. The only sounds rams made were grunting, snorting, and at times, when angry, gnashing of the teeth.

FOOD HABITS

Feeding habits of the bighorn sheep were found to be quite similar to those of the elk so far as choice of forage was concerned. They preferred sedges, grasses, and tender forbs, supplemented by some browse. Practically all of their feeding was done during the day, especially during winter, and at night they bedded down in rough, sheltered areas. Some of the areas near heavily used bed-grounds were definitely overused and overgrazed.

The bighorns were found grazing at all hours of the day and, where forage was plentiful, the feeding periods were rather short, with frequent periods of rest. They have a rather destructive habit of pawing where they feed. This was especially true on open side hills or ridges in granitic soil. Many plants are dug out, some of which may not be utilized, and extensive areas may be pawed over in this manner. This can be explained on areas where feed is scarce, but in other

areas there seems to be no good reason unless the lower portions of some of the plants, such as the clovers, have a higher palatability.

The principal plants grazed were determined mostly by direct observation and "follow-up" methods, since few stomachs were available for analysis of contents. It was found that a wide variety of plant species was included in the bighorns' diet, although certain plants were preferred.

On the summer range, sedges and clover were the most important plants grazed. A few of the others grazed at that time were such grasses as *Festuca spp.*, *Deschampsia caespitosa*, *Kohleria cristata*, *Muhlenbergia montana*, *Calamagrostis canadensis*, *Trisetum spicatum*, and *Poa pratensis*. Browse plants taken were: *Populus tremuloides*, *Ribes inebrians*, *Jamesia americana*, *Rosa* spp., *Picea engelmannii*, and *Salix glaucops*.

A great variety of forbs were grazed on the summer range. Quite noticeable among them were *Polygonum douglasii* (flowers only), *Cersium* spp., *Mertensia siberica*, *Caltha* sp., *Eriogonum* spp. (flowering tops only) and *Myosotis alpestris*.

Newly-opened aspen and engelmann spruce buds appeared to be highly palatable. Rams were observed climbing into dwarf spruce trees at timberline with their forelegs to get to buds they were unable to reach while standing on the ground.

Several stomach samples obtained from sheep illegally killed or taken by predators while on the lower ranges, showed that *Artemisia frigida* was highly palatable and sometimes amounted to 84 per cent of the food taken. Next in order were *Festuca* spp., *Prunus melanocarpa*, and *Muhlenbergia montana*.

Some of the other plants grazed or browsed while sheep were on the lower ranges were: GRASSES.—*Poa pratensis*, *Agrostis* spp., *Calamagrostis canadensis*, *Bouteloua gracilis* and *Blepherneuron tricholepis*. GRASSLIKE.—*Carex filifolia* and *Juncus* spp. FORBS.—*Achillea* spp., *Actinia richardsoni*, *Eriogonum* spp., *Alsine* spp., *Polygonum douglasii*, *Cirsium* spp., *Salsola* and *Leontodon*. BROWSE.—*Ribes inebrians*, *Rubus parviflora*, *Rosa* spp., *Salix* spp., *Jamesia americana*, *Populus tremuloides*, *Dasiphora fruticosa*, *Chrysothamnus* spp., *Pinus ponderosa*, *Pinus aristida*, *Juniperus communis* and *Spirea* sp.

The total stomach contents of a yearling sheep, killed by coyotes, were air-dried and found to weigh approximately six ounces.

Bighorns on winter range did not bother haystacks nor eat hay scattered for cattle. They did eat barley, cut for hay, while in the windrow.

CENSUS

Experiences gained during these studies indicated very definitely that the best time of the year to make a census of the herd was in the fall, or rutting period, especially during the month of November. At that time, sheep were in larger groups, ranged over smaller areas, were mostly at lower elevations, and the rams were with the ewes and lambs. Later, they scattered and were more difficult to find.

Actual counts made in November 1940 showed the following numbers and composition:

Ewes	*Lambs*	*Rams*	*Yearlings*	*Total*
147	80	117	44	388

Based on the number of old ewes counted, the lamb crop at that time was 78 percent. This was encouraging, since the critical period for the lambs had been passed. The increase for the herd, based on the 1939 counts, was approximately 32 percent, a small portion of which was the result of a better census. The count also showed that 70 percent of the 1939 lambs had survived as yearlings.

A few sheep, estimated at 20, not included in the 1940 census, were on a portion of the range not covered at that time. The total number in the herd was close to 400.

LOSSES

Predation.—Coyotes and eagles were common on all portions of the Tarryall range and at least one mountain lion was known to cover portions of the area. Predation was less than might normally have been expected. The known losses during 1940 were two yearlings killed by coyotes and one ewe killed by a mountain lion. These were on the winter range. There were, no doubt, other losses, but none of the coyote scats examined on the summer range, and very few of those from the winter range, contained bighorn sheep hair. Examinations showed that rodents formed the main diet of the coyotes in the area.

The hunting and foot habits of the golden eagles in the Tarryall Mountains were observed and studied with a great deal of interest because many people consider these birds responsible for considerable predation on the bighorn sheep, especially the lambs. During the entire period of this study, not a single eagle was observed to attack or molest the bighorn sheep in any manner. The sheep were not disturbed when eagles came close to them, although the ewes were alert, even when a raven came close to the lambing grounds.

Some eagles nested close to the lambing grounds. One nest was under observation from May 15, at which time the two eaglets were about ten days old, until they left the next early in July. Pellet examinations and actual observations during that period indicated that the eagles were feeding on prairie dogs, which are plentiful in the Tarryall Valley below. The old birds made several trips a day between the nest and the valley, and as many as seven prairie dogs were observed in the nest at one time. The only other item of food found in pellets or at the nest was a trace of rabbit. These observations are not conclusive, but they do indicate that, in the Tarryall Mountains, the eagle is a minor factor.

Poaching.—The known loss from poaching during 1940 was two old rams. These were killed on the winter range during deer season. Local ranchers are proud of the bighorn herd and are responsible for much of the protection that the bighorns receive while on the lower ranges. Few people go into the back country during the summer or fall, and no evidence of illegal killing has been observed on the high ranges. State and Federal officers give all the protection possible to the sheep, and penalties under State laws are quite severe.

Parasites and Disease.—During this study, parasites and disease were responsible for no known loss. The following parasites were present in this herd: *External.*—The winter tick (*Dermacenter albipictus*) was very common, but had no serious effect on the bighorn. Magpies were observed picking ticks from the

sheep during the spring months. *Internal.*—Examination of fecal samples of bighorn sheep from different portions of the range and from many individuals showed the presence of at least four species of coccidia: *Eimeria arloingi*, *Eimeria faurei*, *Eimeria parva* and *Haemonchus* spp. Two species of stomach worms, *Ostertagia marshalli* and *Ostertagia* spp., were found. No lung worms were found.

Three young sheep with a marked diarrhea were found in December 1940. Examination of fecal samples revealed that they had the heaviest parasitic infestation of any samples examined from the Tarryall herd. Six species, four coccidia and two stomach worms, as shown above, were found. The sheep appeared to be in good health otherwise and were able to harbor the parasites with no serious results. No other sick or ailing sheep were observed during the entire study.

RANGE CONDITIONS

Forage in the Tarryall Mountains was found to be sufficient for more than the present number of bighorns. This applies to all types of grasses, forbs, and browse palatable to the sheep and also to both summer and winter ranges. Extensive areas are too rough for domestic stock and snow does not cover the south slopes for long periods during the winter.

Several of the timberline ridges, frequented yearlong by bighorns and in the summer by cattle, have been heavily grazed. Lighter use of those areas seems desirable if the forage resource and the bighorns are to receive proper protection. Some areas on private land in the Tarryall Valley have been severely overused by domestic stock and prairie dogs. Nearby, on the steep slopes, however, there is an abundance of palatable forage available for winter use by the bighorns.

RANGE COMPETITION

Cattle are grazed on the more accessible portions of the bighorns' summer range in the high country and also on some of the winter range, portions of which are privately owned. Prairie dogs are abundant on portions of the lower ranges. A few mule deer are also found in the Tarryall Mountains, but there are no elk and no domestic sheep on the ranges. At the present time, range competition is not at all serious and conflicts are of minor importance.

SUMMARY

Some of the factual data recorded during the study of the Tarryall bighorn sheep were as follows:

1. One-third of the herd ranges yearlong near or above timberline; others migrate to lower ranges for winter.
2. The breeding season is from November 15 to December 20.
3. The sex ratio is approximately even and is partly responsible for the many battles observed.
4. The period of gestation is approximately 180 days.

5. The lambing season is from May 16 to June 15.
6. Ewes first bred at two and one-half years of age.
7. Twin lambs were not observed.
8. Ewes retire to the wildest and most inaccessible areas for lambing.
9. Known losses from poaching, coyotes and mountain lion were small.
10. No evidence of predation by golden eagles was found.
11. Internal parasites found were four species of coccidia and two species of stomach worms. No lung worms were found.
12. The only external parasite found was the winter tick.
13. Magpies demonstrated compatability by removing ticks from the bighorns.
14. Range competition and conflicts are not serious at this time.
15. The herd, almost destroyed in 1923–24, now numbers at least 400 and is increasing.
16. Factors responsible for this increase appear to be: a. sufficient yearlong range for more than the present numbers in the herd, b. favorable conditions and extensive south slopes for winter range, c. no excessive loss from predation or poaching, d. no known loss from disease or parasites, e. excellent lamb crops with indicated survivals of 70 percent as yearlings, f. favorable attitude toward and protection afforded these sheep by the local ranchers.

No one can predict what the future holds in store for the Tarryall bighorn sheep, but, at the present time, it appears to be one of the outstanding herds in the United States and is attracting national attention. Continued favorable conditions, under proper protection and management, during the next few years should result in further increases.

The Tarryall bighorn herd, placed under intensive management and study, would provide valuable factual data, and surplus sheep might be utilized for restocking other areas. State and Federal agencies have such a program under consideration, and it seems highly desirable that a workable management program for this herd be completed and made effective at an early date.

Pike National Forest, Colorado Springs, Colorado.

HISTORY OF A BEAVER COLONY

By David B. Cook

Two centuries of relentless trapping brought the beaver (*Castor canadensis*) to the verge of extinction over most of its range. In New York, once the center of the colonial beaver trade, Radford (1907) reported them reduced to not more than ten individuals.

Rensselaer County (New York) comprises the eastern half of the old Dutch Manor of Rensselaerwyck, of which Albany, once the world's greatest beaver port, was the principal town. Historical records indicate neither the size of the original beaver population nor when they were exterminated. The presumption is that they were cleaned out before the Revolution.

The Grit Plateau, comprising the eastern half of the county, is a rough tableland of metamorphosed Devonian sandstone. Elevations of from 1200 to 2000 feet give the forest a decidedly northern character, with red spruce (*Picea rubra*), white pine (*Pinus strobus*), hemlock (*Tsuga canadensis*) and the northern hardwoods as principal components. Aspen (*Populus tremuloides*) and grey birch (*Betula populifolia*) are conspicuous pioneer species.

In the spring of 1931, the State liberated a pair of dark beaver near the center of the Plateau and so reestablished a valuable resource that had been absent for a long time. This pair were nuisance beaver that had been live-trapped at Wurtsboro, Sullivan County; original stock came from Wisconsin. Subsequently (1931–1933) four other pairs and nine single beaver, all selected dark specimens, were liberated.

This area, with many small streams, extensive woodlands, and a sparce human population, proved to be excellent beaver range. The animals multiplied and spread out over much of the eastern half of the county. There have been some losses, due to conflict with agricultural interests and to sporadic poaching, but for the most part they have lived and multiplied in peace. During the years covered by this record, there was no open season for beaver in Rensselaer County.

In August of 1933 a pair of 2-year-old beaver appeared on my forest, which is situated along Black River, 1½ miles north of Stephentown Center. They dug a burrow and built a small dam across the stream. Since its beginning, the colony has been under constant observation. I have visited it at least monthly for eight years; during the active season visits have been much more frequent. The colony is locally famous and many people have come to see its easily-observed inhabitants. The data here recorded are based on my own observations, but have been checked by other competent observers who are familiar with the colony.

During the 8 years of its recorded existence, the colony had a stable social organization. Although there were strong colonies farther upstream, no outsiders ever intruded. The first year (1933) there was only the original pair. The next year there were adults and kits and thereafter there were adults, yearlings, and kits. Each spring the yearlings, when about 23½ months old, left home to shift for themselves. For a short time thereafter, until the new kits were

born, there were only the adults and the young of the preceding spring. The latter automatically advanced to yearlings when the new litter arrived. Population records are based on the number present about July 1, when the kits were frequently to be seen outside.

This colony is situated on Black River, a 25-foot-wide, boulder-studded stream with a good low-water flow but subject to quick run-off in times of flood. A dirt road runs along the east side of the ponds. On the east bank, between the stream and the road, was a small patch of grass and garden, a little house and a strip of brush (see fig. 1). East of the road the steep hillside was clothed in hemlock forest. On the west side of the stream the gently sloping bank bore a stand of mixed hardwoods with aspen as the principal component, and smaller amounts of red maple (*Acer rubrum*), grey birch, black cherry (*Prunus serotina*) and shadbush (*Amelanchier*). There were also two old white pines, whose progeny formed a scattered advance reproduction under the hardwoods. Farther north were several acres of meadow that had been planted to spruce (*Picea abies*) in 1931. Across these meadows flowed a spring run overgrown with willow (*Salix discolor*), steeplebush (*Spirea*), and alder (*Alnus*). Here the beaver settled down to found a colony, amicably sharing territorial rights with the woodchopper who occupied the cabin on the banks of their pond.

HISTORY OF THE COLONY

1933.—The original pond was impounded in August. As fall approached, the beaver raised their dam until it was 4 feet high in the center and 100 feet long. Part of the wood was dead and fallen material, gathered along the banks; the remainder was new-cut aspen and alder. Numbers of stones and the usual coating of mud were applied to the upstream face. The dam leaked badly until the fall of the hardwood leaves, big drifts of which collected along the crest, became waterlogged and presently sank, effectively sealing the dam. A lodge, 4 feet in diameter and 3 feet high (from the waterline), was built 250 feet upstream from the dam. A few big (10 inch) and many small aspen were cut along the west bank. Storage was close to the downstream side of the lodge. The pond was frozen over by mid-December. The winter of 1933–1934 was unusually long and severe. The small pond, the dam, and all but the top of the lodge were buried in drifts.

1934.—Two young were born in the spring of 1934. During the summer the beaver cut small willow, alder, and aspen suckers along the shore, dredged for tubers, and foraged for clover. In the fall and early winter, they added to the height of both lodge and dam and built a new, low dam 450 feet above the first. As before, aspen was cut along the west bank. The two adult beaver were often seen working together and were very tame. The pond froze over in late December.

1935.—The ice left the ponds in mid-March. Two adults and two yearlings were frequently seen, usually about the lower, deeper pond. Three young were seen out on the lodge on May 5. One cried frequently and appeared sickly. The female was most solicitous, often helping the kit onto the lodge or the shore,

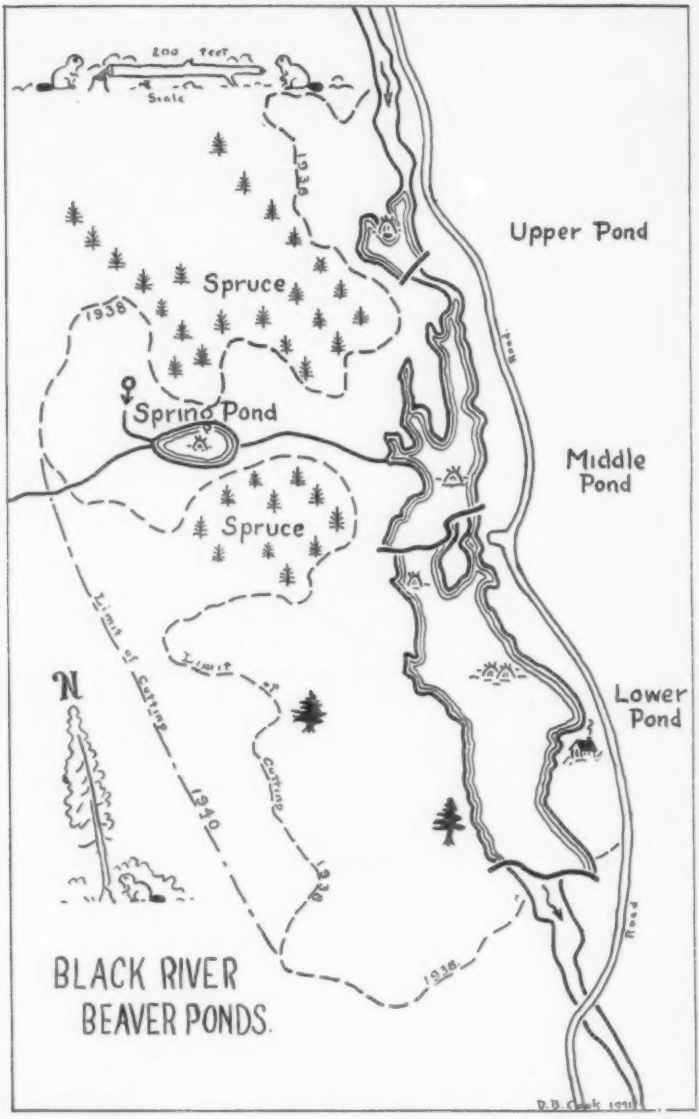

FIG. 1.—Sketch-map of the beaver ponds. Compare with plate 1, opposite

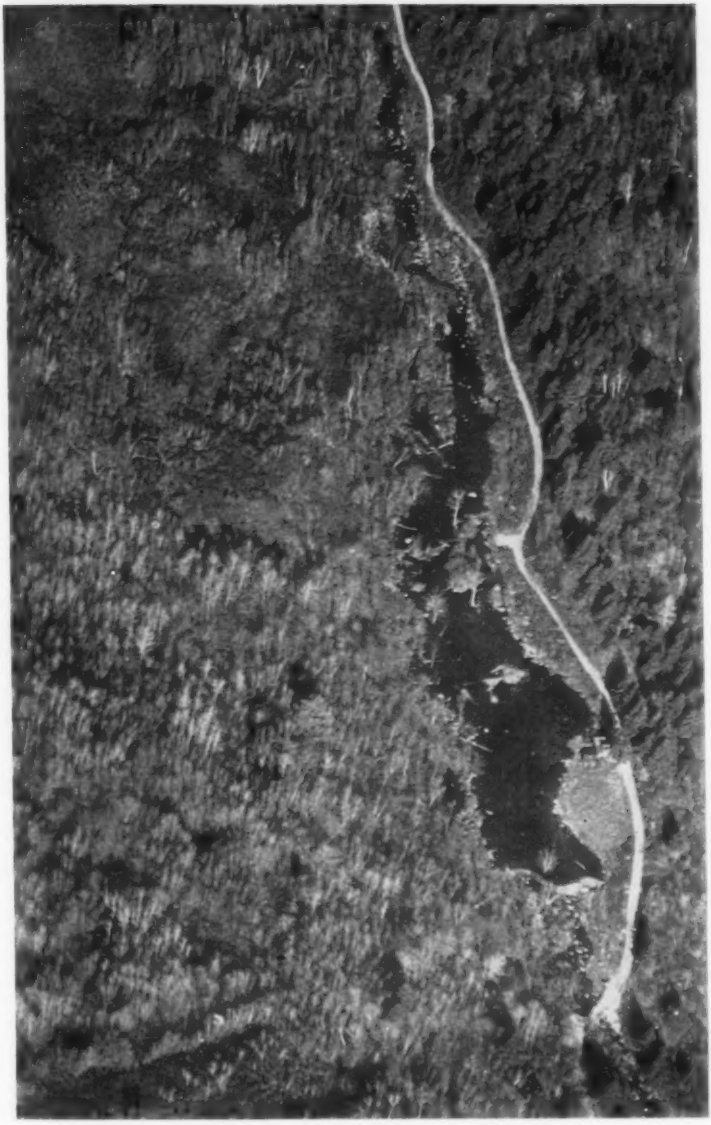

PLATE 1
Aerial photograph of the beaver ponds and surrounding terrain

but the youngster was not seen after the middle of June and presumably succumbed. A flood in July burst both dams and drained the ponds. The beaver immediately repaired and enlarged the lower dam, repaired but did not raise the second dam. In order to tap a supply of aspen on the far side of the meadow, a small and shallow pond was impounded on the spring run by building a low dyke. Their skid road followed the spring run across the flats and down the bank into the pond. In the lower pond a second lodge was built against the west side of the old one, forming a twin. The freeze-up came in early January.

1936.—In March a freshet washed out both dams. Immediate repairs were made to the second dam but the lower pond remained dry all summer. This afforded opportunity to examine the structures and the pond botton. Two kits were born this year. As autumn came the lower dam was rebuilt and water brought up to its former level. A small lodge was constructed in the spring pond. The beaver were now cutting trees well up on the hillside, taking red maple and grey birch as well as aspen and practically clear-cutting some areas. A skid road was opened up, running diagonally up the slope from the west end of the lower dam. This permitted the beaver to tap a patch of aspen that was actually farther downstream than their dam. The ponds were all frozen by December 5.

1937.—No additions were made to the dams or lodges during the spring and summer. There were four kits, bringing the colony to eight. In August the beaver constructed a new dam, above the others. Because of the steep gradient, this upper dam impounded only a small pond. Two burrows were dug into its west bank, one of which was presently converted into a bank lodge. They also raised the middle dam until it was 3 feet high and 120 feet long. Small aspens were cut along the west bank of the middle pond for winter storage.

1938.—This was an open winter and beaver activity was not interrupted. As early as January 30, they were out and working on the twin lodge. Three kits were produced, which with the four yearlings of the 1937 crop and the two adults, brought the number to nine, the most it has ever numbered. On September 21, this section caught the edge of the New England hurricane, which brought the highest flood crest on record. All three dams on Black River were burst and the ponds drained. Winter storage had already begun. The beaver retreated to their little spring pond. They promptly patched the lower and middle dams, which saved such wood as had not been washed away and afforded opportunity for some additional storage in these ponds. The colony was large and food requirements high. The steep hill to the west and northwest of the spring pond bore a dense stand of aspen, upon which the beaver went to work with a will. (In 1939, I salvaged 6 cords of pulpwood from the stems the beaver left.) The lodge in the spring pond was enlarged and a new one built in the middle pond. In mid-December, a cold snap froze the ponds and put a stop to outside activity. I was unable to determine how the beaver divided among the several lodges.

The aerial photo (Plate 1) was taken in October, 1938. The lower, middle, and spring ponds were full, the upper pond was empty.

1939.—By mid-March, and despite inclement weather, the beaver were out

again and cutting aspen west of the spring pond. Only a single kit was born that spring. During the summer the colony lived in the lower and middle ponds, the spring pond having sprung a leak and drained. A new lodge was built in the middle pond. Tree cutting was continued along the margin of the previous cutting to the south and west of the spring pond.

1940.—Two young were born but, because only a single kit had been born in 1939, the colony dropped to five, the lowest since 1934. Wood was again secured along the margin of the former cuttings, this time directly west of the lower dam. The beaver now had to go some 100 yards up the bank, over rough ground, to get aspen. For the first time they did a little summer cutting of willow, yellow birch (*Betula lutea*) and mountain maple (*Acer spicatum*) saplings on the east side of the pond, readily crossing the road to do so.

DISCUSSION

During this 8-year period, the original pair of beaver produced 17 kits, 16 of which grew to adulthood. The record of this colony substantiates the findings of Bradt (1938), who states that "a typical beaver colony consists of an individual family, including the parents, the kits and often the yearlings." The yearlings of this colony left home after the spring breakup each year, before the kits of the year appeared outside the lodges.

The preceding account has traced the major movements of the colony, the hardships entailed by bursted dams and hard winters, the rise and fall of the population. The continuation of a colony is an unending struggle against adversity. A strong colony can construct a dam or lodge or cut a supply of food in a surprisingly short time and can maintain its structures and facilities in good order. But when the strength of the colony ebbs, contraction sets in and the structures fall into disrepair and tend to disintegrate.

During eight years of continuous occupancy, the total area of water impounded in the ponds has never exceeded two acres. The lower pond covered 1.26 acres, the middle, 0.53 acres, the upper, 0.16 acres, and the spring pond only 0.07 acres. The total upland range from which trees have been cut or summer forage gathered is about 9 acres. The cutting has varied from the selection of aspen to practically clear-cutting of all usable material.

SUMMARY

Two years after the reintroduction of beaver into Rensselaer County, New York, a pair of young adults established a colony on Black River, in the southeastern part of the county.

An account of dam and lodge construction, tree cutting, and population is presented. During eight years the original pair produced 17 young. The colony built four dams and five lodges. Occupancy has been continuous despite many mishaps.

The beaver have never had more than two acres of ponded area. They have cut the trees from nine acres of inferior second-growth hardwood land.

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POPULATION TRENDS IN WISCONSIN COTTONTAILS

BY ROBERT A. MCCABE

In 1936 the hunters of Wisconsin noted a marked decrease in cottontails (*Sylvilagus floridanus*). To gain an insight into this scarcity, a group of selected hunters was asked to record, on a standard form, the number of rabbits flushed and the number of hours hunted for each trip afield. The purpose was to get a flushing rate as an index to population. Flushing rates were computed by dividing the number of rabbits flushed by the number of hours hunted. It was hoped that the flushing rates might show a correlation between scarcity and soils, or some other peculiarity of distribution. Such was not the case, however, and this was pointed out by Leopold and Anderson (1938).

The study lapsed in 1937, but hunters and field men noticed that rabbits remained scarce in that year. In the spring and summer of 1938 there seemed to be more rabbits, so the study was resumed and continued in 1939 and 1940.

The accumulated data are shown in Table 1. The last column indicates that the 1936 low continued until 1938 and was followed by higher populations in 1939 and 1940; three-fold higher, if the flushing rate expresses abundance. In any event, a rising trend is evident in the flushing rates for 1939 and 1940.

The cottontail kill for Wisconsin, compiled from hunters' reports by the State Conservation Department, is shown in Curve B, Figure 1. This curve parallels the flushing rate trend during the years 1936 to 1940.

The geographic distribution of flushing rates for each year studied appears in Figure 2. Symbols indicate the flushing rate for each township reporting. Each circle represents an average of 12.6 man-hours afield, but they vary from 4 to 40 man-hours, and hence are not of equal validity. Some townships show a flushing rate only one-tenth that of nearby townships during the same year. This man-hour variation reflects the discrepancies in hunting locale and hunting skill. It also reflects a peculiarity of cottontail ecology that should be noted; that is, the concentration of cottontails at focal points during low years. This localization was observed by Aldo Leopold (unpublished) in 1936 in Juneau and Adams counties. Cottontails were not to be found on the normal range of those counties, but occurred in some numbers in and around towns and villages. I also noted this concentration or spotty grouping of cottontails in a single township, R 16 E T 6 N, in Jefferson County, where I hunted from 1932 to 1941. During the low years 1936 to 1938 inclusive, rabbits could be found only in specific localities, which to the eye appeared to be the same as those not in-

TABLE 1.—*Flushing Rates of Cottontails*

YEAR	QUESTIONNAIRES RECEIVED	NO. OF COUNTIES	NO. OF TOWNSHIPS	TOTAL HOURS AFIELD	COTTONTAILS FLUSHED	FLUSHED PER HOUR
1936	42	32	106	1262	889	0.70
1938	72	43	123	2647	1800	0.68
1939	42	26	157	1155	1977	1.70
1940	51	34	85	876	1378	1.59

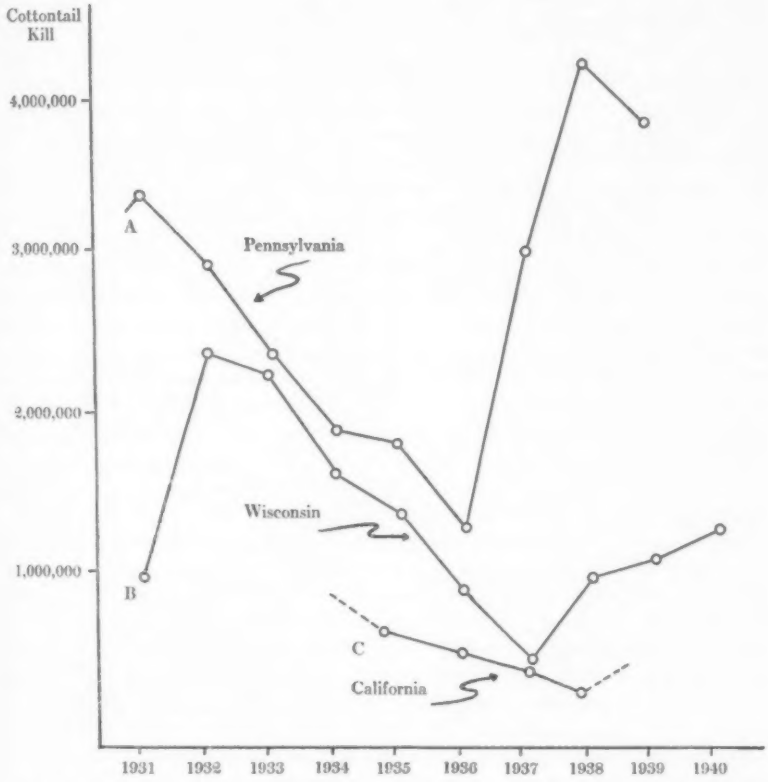

FIG. 1. The annual cottontail kill of Pennsylvania, Wisconsin, and California as taken from the reports of licensed hunters. (Pennsylvania reports from 1931 to 1935 were computed from Gerstell (1937).)

habited. In the higher years, 1932–1936 and 1938–1941, these "focal points" were not apparent, because "good" hunting could be had almost anywhere. During the years this township was hunted, no less than two rabbit dogs were

used, and no less than 50 man-hours were accumulated per week during the open season.

I believe that the shrinkage to "focal points" during low years is a population behavior characteristic of cottontails in southern Wisconsin.

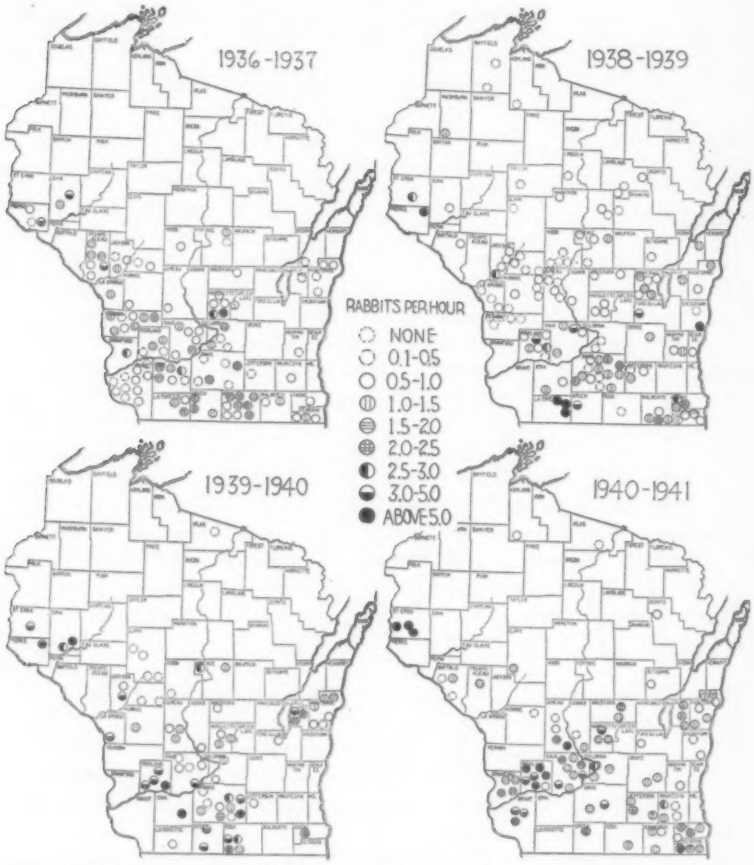

FIG. 2. The average cottontail flushing rate per township as reported by hunters

The factors determining the selection of these focal points are not understood, nor is the manner in which populations concentrate at these points during low years and radiate from them during high years. A study of the population mechanics, carrying capacity, and size of the focal points might help solve some of the problems of cottontail management.

Two epizootics during the years of rabbit shortage were reported. A trapper and weed commissioner in Barron County writes: "In 1933 cottontails were so

numerous that they were a pest. In the summer of 1934 they died off by the thousands. The stink caused by dead rabbits was sickening. The damage they did to young trees and brush during 1933 and 1934 was very great. In 1935 they were very scarce and in 1936 and 1937 they were extremely scarce."

The reliability of this report is not questioned. Whether the writer actually saw a thousand or even several hundred dead rabbits does not obscure the fact that severe die-off was observed, and was followed by several lean years.

From the president of the State Izaak Walton League was received this bit of information: "No one here (West Bend, Washington County) hunted rabbits after November 27, 1938. Shortly before that date a number of rabbits, more dead than alive, were picked up by hunters here, although they could find no apparent outward signs of disease."

These two reports point to the possibility that many unrecorded, perhaps unobserved, epizootics may occur in years of low population.

Tularemia has caused much concern among rabbit hunters. In a rural survey made in the winter of 1940, 50 per cent of 160 farmers interviewed by me gave "rabbit sickness" as a reason for limited or curtailed cottontail hunting. To what extent this attitude prevails among all rabbit hunters is not known.

An interesting comparison between the annual kill of Pennsylvania, California, and Wisconsin appears in Figure 1. The sharpness with which the lines rise and fall is noteworthy, but every bit as significant is the fact that Pennsylvania reaches a high point in 1931, one year before Wisconsin, and after five years' decline (1936) arrives at its lowest point one year before Wisconsin. Wisconsin is at least one year ahead of California. California did not compile the 1939 kill and the recording system was changed in 1940, hence the exact year of extreme low cannot be determined. There is, however, an indication that the low of the last cycle progressed westward. There is also an indication of a westward progression in the preceding high, and in the current high to date.

Chitty and Elton (1937–1940) have recorded the increase and decrease in the arctic fox, snowy owl, and lemming in the Canadian Provinces. Elton (1933–1940) has also recorded the cyclic behavior of the snowshoe hare in Canada since 1933. Their data appear to me to indicate an east-west progression in the highs of the arctic fox, lemmings and the snowshoe hare. They, however, do not claim such a progression. The data merely suggest the existence of such a progression, but by no means prove it. I have found no mention of progression in the literature, and its meaning or importance is not understood.

SUMMARY

1. The flushing rate of cottontails in Wisconsin showed a low population in the years 1936 through 1938, and a three-fold higher population in the years 1939 and 1940.

2. Cottontails concentrated at focal points during the 1936–1938 low.

3. Two known epizootics accompanied the low.

4. Tularemia is causing some rabbit hunters to abandon the sport.

5. The last decade indicates a possible westward progression in highs and lows of the cottontail population across the United States.

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ECOLOGICAL DIFFERENTIATION BETWEEN TWO HARVEST MICE (*REITHRODONTOMYS*) IN WESTERN KANSAS

BY JOHN ERIC HILL AND CLAUDE W. HIBBARD

From July 9 to August 4, 1940, Peter E. Crowe and Hill collected small mammals for the American Museum of Natural History, New York, at a locality 11 to 13 mi. SW of Meade, Meade Co., Kansas. Harvest mice were relatively common that summer; 46 specimens were secured and 6 more were taken by George Rinker and Joe Tihen of the University of Kansas Paleontological Expedition in 1940. In 1941 Hibbard, Rinker and party, University of Kansas Expedition, secured 50 more. The locality has been described and the amphibians, reptiles and mammals reported upon by Tihen and Sprague (1939). They had information on harvest mice only from skeletal elements found in owl pellets, representing what they considered a single species. We took two species: *Reithrodontomys megalotis* in tall grass and weeds; *R. albescens* in short grass and in clumps of prickly pear.

1940 was a good year for the vegetation of the region. For some 15 years the rainfall had been insufficient for wheat crops, soil drifted and much of the country had been allowed to go to weeds (*cf.* Albertson and Weaver, 1942). In 1940, grama grass of two species and buffalo grass were gradually re-covering some of this land, but great weed patches still existed and prickly pear cactus was common. This reclamation, due to favorable weather conditions, continued in 1941.

The vegetational associations of this region are, in order of importance:

(1) Short grass-prickly pear association, found on hillsides and level hilltops. The grass is chiefly blue grama, with some tall grama and buffalo grass. There were large patches of a forgetmenot bur, sea blite and Russian thistle; the mammals appeared to make little use of these weeds. Only the bur was ripe, however.

(2) Sunflower-mallow-tall grass association, found in the smaller, shallow gullies. Here the soil is richer and moisture is retained longer than elsewhere. In

some places the runoff has excavated basins that hold water for some time after rains. The vegetation is dense and masses of dead Russian thistle and sea blite have piled up at the edges of some sunflower patches, extending the cover of the big and little stem grasses.

(3) Moist meadow-riparian association, occurring near the springs and ponds west of Lake Larrabee. Tall grass, sedges and rushes, bordered by bushes and trees, with a heavy growth of weeds constitute the chief vegetation.

(4) Sagebrush-yucca association, found on sandy terraces along the seasonal streams.

(5) Wild plum thickets, restricted to the low, sandy terraces along the seasonal streams. Such areas appear to have more moisture than the sagebrush flats.

Characteristic mammals of the short grass-prickly pear association were:

Sylvilagus audubonii neomexicanus, plains cottontail; found in the prairie dog town and also in the sagebrush.

Cynomys l. ludovicianus, prairie dog. A colony was preserved on a ranch, 14.5 mi. SW Meade.

Citellus tridecemlineatus arenicola, 13-striped ground squirrel; present, but not common, in the short grass.

Perognathus hispidus paradozus, Kansas pocket mouse; relatively common.

Perognathus flavus flavus, Baird pocket mouse; only two were caught in 1941.

Dipodomys ordii richardsoni, kangaroo rat; only moderately common.

Onychomys leucogaster arcticeps, grasshopper mouse; common in the short grass, but less so than in the sagebrush.

Reithrodontomys albescens albescens, pallid harvest mouse. In 1940 about two-thirds (19) of the specimens were taken in traps set at prickly pear clusters. Ten individuals, however, were secured on the edges of sunflower-tall grass areas, or in the adjacent dead Russian thistle; similarly, Kansas pocket mice and grasshopper mice were most commonly taken in short grass, but ranged into the denser cover of the gullies. The pallid harvest mice agree closely with specimens of the typical race from the sandy area of western Nebraska.

In the summer of 1941, 19 specimens were collected by Hibbard, Rinker, *et al*, in the short grass association in this locality. [In September, 1940, traps set at prickly pear clusters and yucca, on dry hillsides near Belvidere, Kiowa Co., secured three specimens of this species.]

Mammals typical of the sunflower-tall grass association, as collected by us, were as follows:

Cryptotis parva, little short-tailed shrew; rare, a single specimen. This was previously known from the area by skulls found in owl pellets.

Sigmodon hispidus texianus, cotton rat; common in this association.

Peromyscus maniculatus nebrascensis, deer mouse; relatively common here but less so than in the sagebrush.

Neotoma micropus canescens, gray wood rat; moderately common in this association. In the area studied all wood rats were living in holes in the sides of gullies; no nests were found on the surface. Some holes were quite large and may afford shelter to cottontail rabbits. The Meade County wood rats agree closely with the type and topotypes of *N. m. canescens*, which come from a nearby locality in the Oklahoma Panhandle (see Blair, 1939), and are quite distinct from the darker typical race, found in Kiowa and Barber counties.

Lepus californicus melanotis, black-tailed jack rabbit. These frequently spend the day in the cover provided by the dense vegetation in the gullies.

Reithrodontomys megalotis aztecus, harvest mouse. Twenty specimens of this species were trapped in the sunflower-tall grass association, or in dead windrows of Russian thistle and sea blite. Two more specimens were trapped near the Cimarron River, south of our locality, by George Rinker, in similar cover. No specimen was taken in the short grass. These specimens agree closely with *R. m. aztecus* from the type locality and adjacent areas and differ from available specimens of *R. dychei* in color and in larger average size. All known topotypes of the latter form are winter-taken, however, and the skins are not comparable to our summer-taken series; we are not at all convinced that *dychei* is a race of *R. megalotis*.

The mammals of the moist meadow-riparian association were the same as those found in the sunflower-tall grass gullies, with the addition of *Sylvilagus floridanus llanensis*, *Geomys*, *Synaptomys*, and *Ondatra*. The commonest mammal was found by Hibbard and Rinker to be *Sigmodon hispidus*, but after these had been trapped out 31 specimens of *Reithrodontomys megalotis*, 8 specimens of *Cryptotis parva*, 19 specimens of *Synaptomys cooperi*, 1 specimen of *Ondatra zibethica cinnamomina* and 3 specimens of *Rattus norvegicus* were taken. No specimen of *Reithrodontomys albescens* was taken in the meadow.

The mammals of the sagebrush association were, in order of abundance: kangaroo rat, grasshopper mouse, deer mouse, jack rabbit, plains cottontail, 13-striped ground squirrel, wood rat, house mouse (*Mus musculus*), and pallid harvest mouse. A single specimen of this latter species was trapped in this association; it was an individual heavily washed with blackish.

In the wild plum thickets tracks of wood rats and kangaroo rats were seen, but no specimens were secured. Jack rabbits used this association for shelter, and in the Meade County Park several eastern cottontails (*Sylvilagus floridanus*), typical of the moist lowlands, were seen in the thickets.

In this report we have not followed Benson's (1935) allocation of *Reithrodontomys albescens* to *R. montanus*. In the large series from the area studied no cranial character or measurement was found that could be relied upon in all cases to separate *R. megalotis* and *R. albescens*, even when animals of the same age-groups were compared, and we think it possible that *R. montanus* is the nominal form of the *megalotis* group. In our locality the paler general coloration, the more ochraceous sides, the indistinct dorsal stripe, the sharply bicolored tail in *albescens* separate it from *megalotis*, even when young animals are considered. These characters may not serve in eastern Kansas. All measurements showed an overlap, although all except that of the cheek teeth gave significant differences in average; in tail length the overlap was slight. Black's (1938) character of a minute accessory cusp on M_1 between the two lateral cusps is valid in about 80 percent of the specimens of *megalotis* with unworn teeth. The baculum (*os penis*) is about one-third shorter in *albescens* (*cf.* Benson, 1939) but only bacula matched with skulls showing well-worn teeth should be considered, since they change considerably between the age when adult pelage is assumed and maturity.

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THE FOOD HABITS OF THE BLACK BEAR IN PENNSYLVANIA

BY LOGAN J. BENNETT, P. F ENGLISH, AND R. L. WATTS

The black bear (*Euarctos americanus*) has become one of the most important big game animals in Pennsylvania. Since 1900 this large carnivore has become increasingly popular with big-game hunters, and the interest of Pennsylvania sportsmen has caused the state to take the lead in managing and utilizing this great animal. As early as 1905, Pennsylvania gave the bear the status of a game animal and protected it as such. The trapping of bears with steel traps was outlawed in 1911, and the use of pen traps was outlawed in 1915 (Gordon, 1922). In 1935, it became illegal to hunt or pursue bears with dogs. Most states have not realized the importance of this animal and consequently have not begun to manage it.

The black bear is found in many of the large forested tracts of Pennsylvania. Most of the bear range today is in the northern half of the state in the predominant beech-maple-hemlock forests. In this area there are good stands of oaks (*Quercus montana*, *Q. rubra*, *Q. alba*, and others) on many of the mountain slopes and particularly on the benches. Much of the terrain in the bear range is rugged with rock outcrops forming many good denning sites and runways.

During the period 1915–1939, hunters in Pennsylvania took 11,321 bears, a yearly average of 452. The average kill during the first 5 years of the 25-year period was 370, and the average kill during the last 5 years of this period was 442. These kill figures indicate that the black bear is holding its own and that the State Game Commission's management program for the species has been a wise one.

The Commission pays for verified damages on livestock and property caused by bears. During the period 1923–1939, the yearly damage payments ranged from $423 to $2,999. Damage claims have been paid on sheep, cattle, hogs, goats, poultry, and beehives; but most of the Pennsylvania bear range is unsuited for livestock, so that the conflict between bears and farmers is not serious. On the other hand, the bear is definitely an economic asset. It has been conservatively estimated that $5,000 is spent by sportsmen in bagging each bear. This money is spent on travel, guns, ammunition, lodging, clothes, and other items.

Each bear season the numbers of hunters seeking this great game animal increases. Because of this greater hunting pressure, the Pennsylvania Game Commission is trying to maintain and increase this resource by developing improved management practices. One of the projects of the Pennsylvania Cooperative Wildlife Research Unit involves the study of the ecology of the black bear. One phase of this work is a study of the food habits of the animal. Only one other paper concerning foods eaten by Pennsylvania bears has been written; that being by Gerstell (1939) on a study of the growth rates of young.

This report covers the analysis of 119 scats collected at all seasons of the year from the fall of 1937 to and including the winter of 1940. The analysis of seven

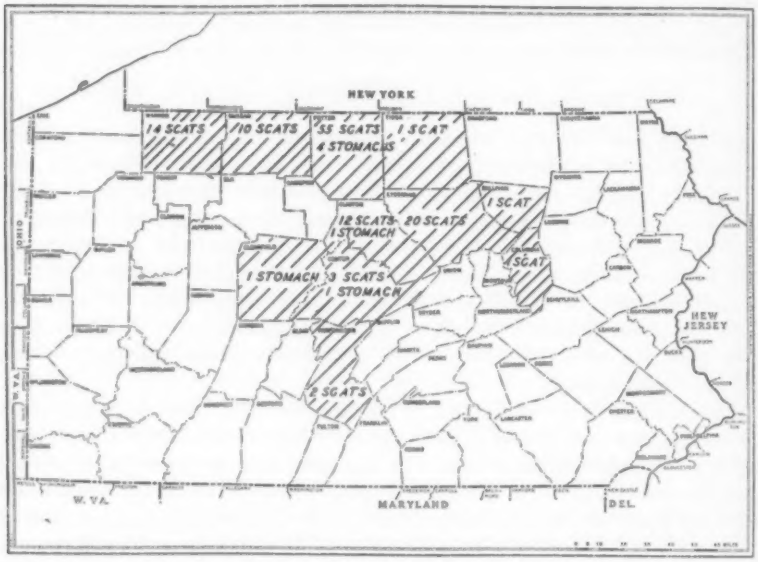

FIG. 1. Where Pennsylvania black bear food habits study material originated

stomachs is also presented. In addition, six freshly dropped scats were collected by R. L. Watts in the fall of 1938 in Aroostock County, Maine; these, too, have been analyzed, and the findings are presented in this article. Sportsmen and game protectors assisted the writers in gathering the food habits material. Mr. John B. Ross, Division Supervisor, Pennsylvania Game Commission, and Mr. Randal McCain, Allegheny National Forest, U. S. Forest Service, were particularly helpful in obtaining material. Figure 1 shows where the Pennsylvania scats and stomachs were collected.

The writers are well aware of the weaknesses of food habits studies based upon the analysis of scats; but such an approach is the only practical one for bears, as the killing of these animals out of season in order to make stomach analyses would indeed be unwise. Stomachs collected during the hunting season are

valuable, but they are usually taken during a 4-day season late in November or early December and therefore information obtained from examination of their contents is not representative of year-long bear feeding habits. The writers

TABLE 1.—*Food remains in 16 scats dropped during the fall of 1937*

ITEM	NO. OF SCATS IN WHICH FOUND	PERCENTAGE OF TOTAL FOOD
Beechnuts (*Fagus grandifolia*)	16	97.6
Wild grape (*Vitis* spp.)	13	2.4
Acorns (*Quercus* spp.)	1	tr
Holly (*Ilex monticola*)	4	tr
Ash (*Fraxinus* sp.)	2	tr
Grass (Gramineae)	1	tr
Maple seed (*Acer* sp.)	1	tr
Unknown insect material	1	tr
Black bear hair	1	tr

TABLE 2.—*Food remains in 21 scats collected during 1938*

ITEM	SPRING		SUMMER		FALL, WINTER	
	1 scat		14 scats		6 scats	
	(a)	(b)	(a)	(b)	(a)	(b)
Wild cherry (*Prunus* spp., mostly *P. serotina*)	—	—	12	91.3	—	—
Acorns (*Quercus* spp., mostly *Q. montana* and *Q. rubra*)	—	—	—	—	3	66.1
Beechnuts (*Fagus grandifolia*)	—	—	—	—	1	6.4
Unknown vegetable matter	1	100	1	tr	1	9.7
Grape (*Vitis* sp.)	—	—	—	—	1	tr
Shadbush (*Amelanchier* sp.)	1	tr	—	—	—	—
Grass (Gramineae)	—	—	12	0.8	—	—
Log	—	—	1	3.4	—	—
Beetles (Coleoptera)	—	—	2	4.5	—	—
Unknown insects	1	tr	1	tr	—	—
Cottontail (*Sylvilagus* sp.)	—	—	1	tr	1	9.7
Unknown hair	—	—	—	—	1	tr
Inert material (gravel, sand, etc.)	—	—	—	—	1	8.1
Crayfish (Crustacea)	—	—	1	tr	—	—

(a) No. of scats in which found.
(b) Percentage of total food.

present the scat-data with reservations; at the same time, they desire to make it clear that such data are better than nothing.

Sixteen scats that had been dropped during the fall of 1937 in Clinton County, Pennsylvania, were collected. Beechnuts (*Fagus grandifolia*) were by far the most common food in them (Table 1). Nine items were found, of which the residue of beechnuts constituted 97.6 percent of the total volume. Beech trees produced an excellent crop of nuts in 1937, but from that time to the present

the production has been very light. Apparently bears forsake almost all other foods for beechnuts when they are available. Bears commonly climb trees after nuts and apples.

Only one scat was collected in the spring of 1938. This was too small a sample, and the material in it was unidentifiable. Fourteen scats were collected during the summer of 1938. Wild cherry (*Prunus* spp., mostly *P. serotina*)

TABLE 3.—*Food remains in 53 scats collected during 1939*

ITEM	SPRING		SUMMER		FALL, WINTER	
	3 scats		22 scats		28 scats	
	(a)	(b)	(a)	(b)	(a)	(b)
Acorns (*Quercus* spp., mostly *Q. montana* and *Q. rubra*)	—	—	10	33.7	20	55.4
Wild cherry (*Prunus* spp., mostly *P. serotina*)	—	—	9	51.1	4	2.6
Beechnuts (*Fagus grandifolia*)	—	—	—	—	4	20.4
Cultivated apple gone wild (*Malus* sp.)	—	—	1	.4	6	12.3
Shadbush (*Amelanchier* sp.)	1	8.3	3	7.1	—	—
Grasses (Gramineae)	—	—	—	—	2	6.2
Wild grape (*Vitis* sp.)	—	—	3	0.4	4	2.4
Holly (*Ilex monticola*)	—	—	2	0.9	2	tr
Dogwood (*Cornus* sp.)	—	—	1	4.4	—	—
Chokeberry (*Pyrus* sp.)	—	—	—	—	1	tr
Sumac (*Rhus glabra*)	—	—	—	—	1	tr
Black locust (*Robinia pseudo-acacia*)	—	—	—	—	1	tr
Blackberry (*Rubus* sp.)	—	—	1	tr	—	—
Hawthorn (*Crataegus* sp.)	—	—	2	0.3	—	—
Arrow-wood (*Viburnum nudum*)	—	—	1	0.4	—	—
Inert material (gravel, sand, etc.)	1	82.3	—	—	—	—
Unknown insects	1	6.3	—	—	—	—
Beetles (Coleoptera)	1	tr	1	tr	1	tr
Bees (Hymenoptera)	—	—	—	—	2	.7
Woodchuck (*Marmota monax*)	—	—	1	0.2	1	tr
Deer (*Odocoileus virginianus*)	—	—	—	—	1	tr
Unknown hair	1	3.1	—	—	2	tr
Crayfish (Crustacea)	—	—	1	tr	—	—
Unknown fruit	—	—	1	tr	—	—
Misc. (roots, vegetable debris, etc.)	—	—	1	0.9	—	—

(a) No. of scats in which found.
(b) Percentage of total food.

pits and skins were the most abundant material in the scats; remains of this fruit made up 91.3 percent of the total volume. Six other items were recorded, but they were almost incidental. Six scats were collected during the fall and winter of 1938; in these, acorn (*Quercus* spp., mostly *Q. montana*) remains constituted 66.1 percent of the total volume. A light crop of beechnuts was produced in 1938 and this was reflected in the food of the bear as 6.4 percent of the scat material consisted of the remains of these nuts. One scat contained fragments of a cottontail (*Sylvilagus floridanus*), which made up 9.7 percent of the total volume. A summary of the 1938 data is presented in Table 2.

The fruit of shadbush (*Amelanchier canadensis*), together with insects, constituted the bulk of the identifiable material in the three scats collected during the spring of 1939 (Table 3). In 22 scats collected during the summer of 1939, wild cherry fruits led the list of foods, with a percentage of 51.1. Acorns also contributed heavily to the diet as their hulls made up 33.7 percent of the volume. In 28 scats collected during the fall of 1939, acorn remains constituted 55.4 percent of the total volume. That year the beechnut crop was spotty, being

TABLE 4.—*Food remains in 30 scats collected during 1940*

ITEM	SPRING		SUMMER		FALL, WINTER	
	7 scats		8 scats		15 scats	
	(a)	(b)	(a)	(b)	(a)	(b)
Acorns (*Quercus* spp., mostly *Q. montana* and *Q. rubra*)	5	44.7	—	—	3	23.6
Wax (including bees)	—	—	1	34.5	—	—
Holly (*Ilex monticola*)	1	tr	—	—	1	.6
Wood	—	—	1	9.1	—	—
Corn (*Zea mays*)	—	—	1	tr	1	.7
Blackberry (*Rubus* sp.)	—	—	1	13.8	1	tr
Sassafras (*Sassafras officinale*)	—	—	1	tr	1	tr
Wild cherry (*Prunus* spp., mostly *P. serotina*)	—	—	3	15.8	—	—
Dogwood (*Cornus* spp., mostly *C. florida*)	—	—	2	tr	6	4.8
Cultivated apple gone wild (*Malus* sp.)	—	—	2	9.6	10	31.1
Grasses (Gramineae)	—	—	—	—	6	tr
Poison ivy (*Rhus toxicodendron*)	—	—	—	—	2	tr
Wild grape (*Vitis* sp.)	—	—	—	—	3	34.5
Unknown vegetable matter	3	32.2	1	tr	1	tr
Roots	1	tr	—	—	—	—
Debris	—	—	—	—	1	tr
Unknown seeds	—	—	1	tr	—	—
Woodchuck (*Marmota monax*)	—	—	2	17.2	—	—
Deer (*Odocoileus virginianus*)	1	23.0	—	—	3	5.3
Unknown hair	1	tr	—	—	1	tr
Black bear hair	—	—	1	tr	—	—
Beetles (Coleoptera)	1	tr	4	tr	—	—
Unknown insects	—	—	2	tr	1	tr

(a) No. of scats in which found.
(b) Percentage of total food.

good in few areas, and only 20.4 percent of the volume was composed of this food. Some wild cultivated apples were eaten, also, as a pomace made up 12.3 percent of the volume for the series of scats.

In seven scats that had been dropped in the spring of 1940, acorn remains made up 44.7 percent of the volume and white-tailed deer (*Odocoileus virginianus*) hair made up 23 percent. (The deer occurrence probably represented carrion, for many of these animals died of starvation during the previous winter). Analysis of eight scats collected during the summer revealed that wax and bees constituted 34.5 percent of the volume. Woodchuck (*Marmota monax*) re-

mains made up 17.2 percent of the volume; wild cherry, 15.8 percent; blackberry (*Rubus* sp.) seeds, 13.8 percent; and wild cultivated apple pomace, 9.6 percent. In obtaining apples from trees, the bear usually does a crude job of pruning: the feeding bear pulls the branches in to the tree, twisting, bruising, and breaking them. Corn (*Zea mays*) was recorded only once and then as a trace, although each year the Pennsylvania Game Commission gets reports concerning bears that learn to eat and like ear corn in the milk stage. Bears acquiring the corn-eating habit do considerable damage to cornfields in some areas.

Fifteen fall and winter scats were collected in 1940 (Table 4). The apple crop in 1940 was one of the greatest in the history of apple raising in Pennsylvania and the wild apple trees likewise produced an abundant crop. Wild grapes (*Vitis* spp.) were also abundant in 1940. Remains of these two fruits made up 31.1 percent and 34.5 percent, respectively, of the total volume of the above mentioned scats. The acorn crop was light and the remains of acorns composed 23.6 percent of the volume in 1940. The hair of white-tailed deer made up 5.3 percent of the volume. (The deer were probably eaten as carrion obtained as a result of crippling losses during the deer-hunting season.)

TABLE 5.—*Contents of 7 bear stomachs taken in November 1939 and November 1940*

ITEM	NO. OF STOMACHS IN WHICH FOUND	PERCENTAGE OF TOTAL FOOD
Acorns (*Quercus* spp.)	5	55.6
Deer (*Odocoileus virginianus*)	3	43.0
Apples (*Pyrus malus*)	1	1.3
Leaves and twigs	1	tr
Bees (Hymenoptera)	1	tr

R. L. Watts collected six freshly dropped scats in Aroostock County, Maine, in October 1938. The remains of beechnuts made up 61.1 percent of the volume of these scats. The bulk of the residue consisted of unidentified vegetation and grasses. It is interesting to note that only 6.4 percent of the volume of Pennsylvania bear scats was composed of beechnuts that fall and winter. This merely points out the fact that certain food species may produce heavily in some areas and, at the same time, be almost absent in other regions. Cottam, Nelson, and Clarke (1939), in reporting on the foods of the black bear on the George Washington National Forest, Virginia, during November and December 1935–1938, did not record beechnuts, but reported acorns as the most often taken food.

Three bear stomachs were collected in Pennsylvania in November 1939; four more were collected in November 1940. No conclusions can be drawn from such a small series, but an analysis is presented in table 5 for general interest.

SUMMARY AND DISCUSSION

The analyses show that the summer scats, 1938–1940, contained five predominant species. Wild cherries made up 52.7 percent of the volume; acorns, 12.6 percent; wax and bees, 11.5 percent; woodchuck, 5.7 percent; and blackberry, 4.6 percent.

The material found in fall and winter scats, 1937–1940, included acorns, 36.3 percent; beechnuts, 31.1 percent; apples, 10.9 percent; and wild grapes, 9.2 percent.

Scat material collected in spring was not sufficient to warrant discussion.

Comparatively few plant species produce food that is available to bears during the fall, winter, and early spring. At present, four groups of plants in Pennsylvania are sufficiently abundant and productive to provide food over much of the bear range during the dormant months, these being the oaks, beech, apples, and grapes. The oaks and beech are by far the most important, but the beech is a very unstable producer, and the oaks do not produce heavily each year. At one time the chestnut (*Castanea dentata*) probably filled the gap, particularly in years when beechnuts and acorns were scarce. Apples are an important food, especially when they carry the load through years of unfavorable production of other species. Apple trees are found throughout Pennsylvania forests, along old logging roads and around abandoned homesteads. The trees along the trails and roads originated from seeds of apple cores thrown to the side by woods workers during earlier logging operations. Pennsylvania has many areas of beech that will begin to produce nuts in a few years. As the years go by, greater crops of beech mast will be produced during favorable mast years. To a smaller degree, this can also be said for the oaks. Grape and apple production will probably decline because such species are crowded out by climax forest species.

Wild cherries appear to be the most important summer food of bears in Pennsylvania. Our foresters should consider the cherry as an important forest tree, not necessarily for its timber value, but because it is a part of a balanced biotic community. The bear is only one species that utilizes the cherry. Many other mammals and scores of birds get part of their sustenance from this source.

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COMPARISON OF TREE CUTTINGS OF SIX BEAVER COLONIES IN ALLEGANY STATE PARK, NEW YORK

By Albert R. Shadle, Alma M. Nauth, Edward C. Gese and Thomas S. Austin

The lack of much definite information on food and tree cutting activities of the beavers led the senior author in 1937 to begin observations on a new colony. The first data taken involved only the one colony (Shadle and Austin, 1939), but to June 3, 1941, information on five more colonies has been obtained and a comparison of all these data is the basis for this paper.

The time involved in the data varies from 49 months each in colonies one, two, and three; 14 months in number four; 13 months in number five; 8 months in colony number six. The total time of all six colonies amounts to 182 months or fifteen years and two months of colony activity.

CUTTINGS PER COLONY

The total recorded cuttings of the six colonies (Table 1) amount to 5,424 trees having a diameter of 1 to 17 inches across the cut stump. Nothing less than one inch in diameter was counted and, because of this limitation on the measurement of material recorded, the results given here represent a minimum rather than the maximum of the cutting done. While the bark and leaves form by far the greater portion of the beavers' food material, not all of the food value of the cuttings is utilized, as measured by Aldous (1938). This waste of food material may be due to several factors: (a) trees may fall in such a position that the beaver cannot use them; (b) trunks may be too large to handle and the bark so corky that younger, more desirable food is taken instead; (c) limbs and trunks may be used in lodge building and damming without removal of the food material; (d) so much material is cut at times that drying out spoils its food value before it is used.

It is impossible to determine the exact amount of cuttings used for food, the amount wasted, the amount used in lodge and dam construction and in repair work. Because (a) no satisfactory method is available for measuring the *bark-and-leaf* food value in relation to the diameter of the tree, (b) and because the volume of the tree is of little aid in estimating its food value and (c) because beyond a diameter of five inches, the greater the diameter of the tree, the greater will usually be the trunk waste, one is left mainly with the comparison of the different genera of trees cut, the numbers of trees per genus, and the diameters of the trees cut. The number and size of individual beavers per colony, the location of the colony, as in colony number two, the kinds and the sizes of the trees present, and the amount of wasted food material, all are important factors in determining the amount of cutting done by a colony.

COLONY NUMBER ONE

This colony started in an area having plenty of *Populus* and *Salix* and 25 or more other genera of trees common to the region. During 49 months, 1,584 trees

TABLE 1.—*Comparative Tree Cuttings of Six Beaver Colonies in Allegany State Park, New York*

COLONY	No. 1 Quaker Run	No. 2 Quaker Lake	No. 3 Upper Red House Creek	No. 4 Owasaka	No. 5 Lower France Brook	No. 6 Upper Quaker Run
DATES	April '37 to June 3, '41	April '37 to June 3, '41	April '37 to June 3, '41	March '40 to June 3, '41	April '40 to June 3, '41	Oct. 9, '40 to June 3, '41
TIME IN MONTHS	49	49	49	14	13	8
Trees	*Populus* 593 *Carpinus* 302 *Amelanchier* 278 *Salix* 182 *Betula* 68 *Prunus* 56 *Fagus* 53 *Acer* 47 *Hamamelis* 3 *Tsuga* 2	*Carpinus* 240 *Acer* 145 *Prunus* 85 *Betula* 74 *Amelanchier* 43 *Fagus* 43 *Hamamelis* 32 *Ostrya* 13 *Tsuga* 12 *Tilia* 9 *Salix* 9 *Populus* 8 *Pinus* 1 *Fraxinus* 1	*Carpinus* 643 *Populus* 424 *Acer* 215 *Amelanchier* 170 *Betula* 106 *Tsuga* 103 *Salix* 96 *Prunus* 66 *Fagus* 17 *Hamamelis* 16 *Ostrya* 9 *Ulmus* 6 *Tilia* 2 *Pyrus* 2 *Fraxinus* 1	*Populus* 302 *Betula* 35 *Salix* 34 *Acer* 28 *Carpinus* 24 *Amelanchier* 23 *Hamamelis* 15 *Prunus* 6 *Pinus* 2 *Picea* 1 *Tsuga* 1 *Fraxinus* 1	*Populus* 392 *Salix* 160 *Carpinus* 40 *Prunus* 19 *Amelanchier* 9 *Acer* 3 *Pyrus* 3 *Tsuga* 1 *Hamamelis* 1	*Populus* 115 *Salix* 16 *Carpinus* 8 *Prunus* 4 *Acer* 4 *Amelanchier* 1 *Betula* 1
Total	1584	715	1876	472	628	149
Waste cuts	19	13	38	2	0	4
Percent waste cuts	1.2	1.8	2.0	0.4	0	2.5
Genera per colony	10	14	15	12	9	7

of 10 genera have been cut. The first six genera are *Populus*, 593; *Carpinus*, 302; *Amelanchier*, 278; *Salix*, 182; *Betula*, 68; and *Prunus*, 56. As the first four have been practically exhausted, the beavers are turning more and more to *Betula*, *Fagus*, *Acer*, etc.

During this time eight young have been produced by the original pair.

COLONY NUMBER TWO

This colony is located on a small, deep, artificial lake, the high banks of which make an excellent site for a bank lodge, and bank burrows. Since deep water is always available for food storage, there is no need for dam construction. The *Populus* supply here consisted of only eight trees, and a very sparse supply of *Salix* grew at the east end of the lake. This lack of poplar and willow was caused by the preliminary destruction of trees and brush on the lake bed when it was prepared and the flooding of the area to a depth of over 20 feet.

This colony is unusual in several ways: (1) Lacking *Populus* and *Salix*, it used much greater numbers of twelve other genera for food; (2) no damning operations were ever undertaken and not more than 15 cubic feet of material were ever used on the single bank lodge, thus all the cuttings were probably used for food; (3) *Carpinus*, 240; *Acer*, 145; *Prunus*, 85; and *Betula*, 74, were the main food supply from the 14 genera of trees used; (4) the small number of cuttings (715) in 49 months is due to, (a) the presence of only two adult beavers and (b) no necessity for damming and building activities. The total, 715 cuttings, is much less than half the cuttings made by colonies one and three in the same length of time. (5) No young were ever seen at this colony although it was under continual observation each summer. Since no young were produced, and since the diet was quite lacking in the two important food plants, the point is suggested that an element essential for reproduction may be lacking in their food supply.

If these beavers are of the same sex, they are living within half a mile of another colony and there is ample opportunity for the selection of mates.

The general activities and reactions of the two were similar to those of other known pairs and it is believed that these two also are a pair.

COLONY NUMBER THREE

This colony had a plentiful supply of many kinds of trees, and of the 15 genera used there were 1,876 trees, the largest number cut by any colony. Since there were plenty of *Populus* and *Salix* present and many of the poplars were large ones (7″–15″ diam.), the numerical order of the cuttings was rather unusual. It was *Carpinus*, 643; *Populus*, 424; *Acer*, 215; *Amelanchier*, 170; *Betula*, 106; and *Tsuga*, 103. The comparatively large number of hemlock cut, and the degree to which the bark had been stripped from the roots and as high as they could reach on the trunks, seemed ample evidence of the use of hemlock bark for food. Trees were often completely skinned at the base and killed, although they were not always cut down.

The large number of *Carpinus* cut by this colony is rather striking and was mentioned in an earlier paper (Shadle and Austin, *op. cit.*).

The number of beavers in this colony is not known.

COLONY NUMBER FOUR

The small area in which this colony settled was well supplied with *Populus*, some *Salix* and the usual other genera were present. Of the 472 trees, *Populus*, 302, formed the main source of cuttings, but *Betula*, 35; *Salix*, 34; *Acer*, 28; *Carpinus*, 24; *Amelanchier*, 23; and six other genera have been used. A decided preference for *Populus* is shown and the first six genera on the general preference list are also the first six on this list. This colony probably has enough material to remain in this location only about two years, for the poplar is almost entirely depleted and they must soon turn to other less desirable food trees or seek a new location.

There were two adults and two young in this colony.

COLONY NUMBER FIVE

The abundant supply of poplar and large willows is evident in the cutting-list of this colony. Of the 628 cuttings, *Populus*, 392; *Salix*, 160; and *Carpinus*, 40, make up 90 percent of the cuttings. Nine genera were used.

COLONY NUMBER SIX

This colony settled in September and promptly built a long dam and a lodge and in eight months have cut 149 trees. Here *Populus*, 115; and *Salix*, 16, furnish 87 percent of the total cuttings.

DISCUSSION

The importance of "availability" (Hamilton, 1939) in the determination of the food supply stands out prominently here (Table 2) and, while 17 genera and probably 25 species of trees were used, 7 genera furnished 93 percent of the cuttings. Two genera, *Populus* (33.8 percent) and *Carpinus* (23.1 percent) supplied 56.9 percent of the total of 5,424 cuttings. The large percentage of *Carpinus* compared with *Salix* (9 percent) was due to two factors: (a) most of the *Salix* used was less than one inch in diameter, and (b) small amounts of *Salix* were available in colonies nos. 2, 4, and 6.

In the numerical list of cuttings *Carpinus* was first in two colonies, second in one, third in two and fifth in one. In no other lists except Shadle and Austin (1939) has *Carpinus* or *Amelanchier* been cited as important items in beaver food, but the high percentages of these two genera and the great amounts of peeled branches found indicate that they are much used for food, as well as for construction at Allegany State Park, N. Y.

These findings substantiate Bradt's contention (1938) that, "It is seldom feasible to distinguish between various usages of material," such as food, construction, and repair of lodges and dams, because of the inability to determine the definite amounts used for each item. In these data the cuttings include a considerable range of trees, but again "their preferences are for a comparatively small number of trees" (Bradt, *op. cit.*). This numerical list as an order of preference, *Populus*, *Carpinus*, *Amelanchier*, *Salix*, *Acer*, *Betula*, and *Prunus*, differs slightly both from Bradt's (*op. cit.*) "aspen group, maples, and willows," and from Shadle and Austin's (*op. cit.*) "poplar, willow, shadbush, ironwood and

cherry." In the latter list, both large and small willows were included when placing *Salix* in second place. By the same calculations *Salix* would be in second or third place in the present list, instead of fourth place. Where plenty of *Populus* and large *Salix* are present, they occur in this order of preference, as in colonies five and six. Small size of much of the willow taken often modifies the preference list.

TABLE 2.—*Tree Cuttings of Six Beaver Colonies Compared By Genera*[1]

GENERA OF TREES CUT	COLONIES						TOTALS PER GENUS	PER CENT OF TOTAL
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6		
Populus	593	8	424	302	392	115	1834	33.8
Carpinus	302	240	643	24	40	8	1257	23.1
Amelanchier	278	43	170	23	9	1	524	9.6
Salix	182	9	96	34	160	16	497	9.0
Acer	47	145	215	28	3	4	442	8.0
Betula	68	74	106	35	—	1	284	5.2
Prunus	56	85	66	6	19	4	236	4.3
Tsuga	2	12	103	1	1	—	119	2.0
Fagus	53	43	17	—	—	—	113	2.0
Hamamelis	3	32	16	15	1	—	67	1.2
Ostrya	—	13	9	—	—	—	22	0.4
Tilia	—	9	2	—	—	—	11	0.2
Ulmus	—	—	6	—	—	—	6	—
Pyrus	—	—	2	—	3	—	5	—
Pinus	—	1	—	2	—	—	3	—
Fraxinus	—	1	1	1	—	—	3	—
Picea	—	—	—	1	—	—	1	—
Total cuts per colony	1584	715	1876	472	628	149	5424	100
Genera per colony	10	14	15	12	9	7		
Waste cuts	19	13	38	2	0	4	76	1.4
Approx. time in months	49	49	49	14	13	8		

Total number of genera cut by all six colonies: 17.
[1] Data to June 3, 1941.

In the Superior National Forest, Aldous (1938) found the order of preference aspen, white birch, alder and willow.

It is quite generally believed that only rarely, when other food is scarce, is coniferous material used as food and Seton (1909) says that the beaver "never is known to eat any part of a coniferous tree."

To the contrary, Warren (1927) states that he has found "numerous lodge pole pines from which the beaver have removed some of the bark, even when other food was close at hand." He concludes that "the beaver makes much more use of the conifer bark than it has been supposed to do." Our observations with regard to the use of the conifers is decidedly in agreement with Warren.

Numerous hemlocks were found, both cut and uncut, where the bark had been removed from the base of the tree and stripped as high as the strength of the bark strand would permit the beaver to tear it loose. The stripping of the bark was also carried along the roots even to a distance of two to four feet from the base. This method of stripping the bark off the trunk and roots is similiar to that described by Warren and, since this is the way in which food material is usually handled and since none of the hemlock bark was seen about the lodges or dams, it was believed that it was probably used as food. Although this was observed in most of the colonies, colony number three showed more of this evidence than any of the others.

TABLE 3.—*Beaver cuttings as per genus and size distribution*

STUMP DIAM. IN INCHES	GENERA																	TOTALS	PERCENTAGE
	Populus	Carpinus	Amelanchier	Salix	Acer	Betula	Prunus	Tsuga	Fagus	Hamamelis	Ostrya	Tilia	Ulmus	Pyrus	Pinus	Fraxinus	Picea		
1–1.9	476	810	282	478	330	110	136	49	65	60	16	7	4	2	1	3	1	2830	52.1
2–2.9	465	339	130	17	63	79	34	35	34	5	3	2	2	1	2	—	—	1211	22.3
3–3.9	281	77	51	2	29	40	16	11	8	2	2	1	—	—	—	—	—	520	9.6
4–4.9	175	22	42	—	11	24	11	8	3	—	1	—	—	—	—	—	—	297	5.4
5–5.9	116	5	11	—	6	9	8	7	2	—	—	—	—	—	—	—	—	164	3.0
6–6.9	103	4	1	—	2	12	9	4	1	—	—	—	—	—	—	—	—	136	2.5
7–7.9	58	—	3	—	1	3	5	3	—	—	—	—	—	—	—	—	—	73	1.3
8–8.9	39	—	3	—	—	4	14	2	—	—	—	—	—	—	—	—	—	62	1.1
9–9.9	34	—	1	—	—	1	—	—	—	—	—	1	—	1	—	—	—	38	—
10–10.9	35	—	—	—	—	1	1	—	—	—	—	—	—	1	—	—	—	38	—
11–11.9	10	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	12	—
12–12.9	21	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	22	—
13–13.9	11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	—
14–14.9	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—
15–15.9	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—
16–16.9	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Total	1834	1257	524	497	442	284	236	119	113	67	22	11	6	5	3	3	1	5424	

Under "Waste Cuts" is recorded the number of cut trees which fell in such a position that the beaver could not utilize them. The comparatively open growth in this area has resulted in a low percentage of waste. The percentages of waste per colony varied from 0.0 percent to 2.5 percent with an average of 1.4 percent for the total cuttings of all six colonies. The largest percentage noted in any colony, at any time, was 3.4. This represents a remarkably low waste when one considers that Aldous (*op. cit.*) gives aspen 29 percent and white birch 22 percent as "complete waste." Bradt (*op. cit.*) states that in heavy stands of aspen "sometimes nearly half of the trees cut in a given acre are lodged and wasted."

Aldous (*op. cit.*) formulated a method of determining the amount of food

available in the twigs and bark of *Populus* and *Alnus* trees in the winter condition. While trees are in leaf the amount of leaves taken with the bark and twigs would modify more or less the available food material, so that a correction should be made from Aldous' figures when the trees are cut and used during the leaf bearing period. This will be the subject of a later study.

A chart of the cuttings per genus arranged according to diameter of stump (Table 3) gave the following figures as to the size distribution of the cuttings.

SIZE	CUTTINGS	PERCENTAGE
1 in.	2830	52.1
2 in.	1211	22.3
3 in.	520	9.6
4 in.	297	5.4
5 in.	164	3.0
All larger diams.	402	7.6

Of the 5,424 trees, 4,041 or 74.4 percent were less than three inches in diameter; 4,561 or 84 percent were less than four inches in diameter. Only 7.6 percent had a diameter of six inches or more.

SUMMARY

1. The tree cuttings of six colonies of beavers in Allegany State Park, New York, involving a sum total of 15 years and 2 months of colony activity, are compared.

2. The total cuttings amounted to 5,424 trees, measuring from 1 to 17 inches in diameter.

3. A total of 17 genera of trees was cut for food, construction, and repair.

4. Two genera, *Populus* and *Carpinus*, furnished 56.9 percent of the total cuttings.

5. Seven genera in the following order of preference, *Populus*, *Carpinus*, *Amelanchier*, *Salix*, *Acer*, *Betula*, and *Prunus*, furnished 93 percent of the total cuttings.

6. As the depletion of the preferred genera progresses, the gradual shift to the less desirable genera is evident.

7. Two genera, *Carpinus* and *Amelanchier*, prominent on this list, are not mentioned on the other lists except that of Shadle and Austin (1939).

8. Contrary to a prevalent idea that conifers are not used as food, *Tsuga* bark appears to be a definite source of food in these colonies.

9. The total "waste cuts" of the 5,424 cuttings of all six colonies amount to 76 trees, 1.4 percent of all trees felled.

10. Of 5,424 trees, 4,041 or 74.4 percent were under three inches in diameter; 4,561 or 84 percent were less than four inches in diameter; 402 trees or 7.6 percent were six inches or more in diameter.

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WEIGHT DATA ON FIVE WHALES

BY DANIEL P. QUIRING

During the summer of 1941, Dr. George Crile of the Cleveland Clinic Foundation organized an expedition to Fields Landing, California, for the purpose of making anatomical observations and securing weight data on whales. The party making up the expedition were Dr. and Mrs. Crile, James Barrett, and D. P. Quiring.

A whaling station is maintained at Fields Landing and with the cooperation of its staff it was possible to take five whales in 12 days. Three of these animals were humpback whales (*Megaptera nodosa* Bonn), one was a sperm whale (*Physeter catodon* Linne), and one was a finback (*Balaenoptera physalus* Linne).

BODY WEIGHTS

Obviously it is difficult to determine accurately the body weight of a whale. Whalers generally follow the rule of assigning one ton of weight per lineal foot in estimating the body weight of adult whales. We used this rule for weight estimation of four specimens. This procedure appears to be fairly accurate for the humpback; the girth of the animal is relatively large in comparison to its length, and the body undergoes an abrupt tapering toward the tail. The sperm whale, on the other hand, shows a much greater degree of streamlining, giving the animal a relatively lesser girth for a given length. Our sperm and humpback whales ranged in length from 41 to 46 feet. The finback, on the other hand, measured 71 feet in length. It was decided to make an actual body weight determination of this animal. For this undertaking, we had the complete cooperation of the whaling station staff under direction of Mr. A. D. McBride, manager of the station. Without such aid the task would have been impossible.

Two Fairbanks-Morse platform scales of 1000 pounds capacity, and one Chatillon dynamometer of 600 pounds capacity were employed. Small glands were weighed on a Chatillon autopsy scale. The weights were carefully recorded by three of us, and the entire task was accomplished in two days. The whaling crew stripped blubber and muscle, disarticulated the animal in the usual manner, and sectioned the tissues into pieces convenient to handle. Body fluid and blood loss were considerable, and estimates were made for this loss. The weather

was cool and the sky overcast during this period, and the tissues did not suffer any undue drying.

The procedure in flensing is quite specific. The chief flenser directs a series of cuts through the blubber following the long axis of the body. The blubber is removed in long strips with a power winch, one or two flensers freeing the tissue as the winch peels it from the underlying muscle. Included with the blubber is the outer skin layer. Following removal of the blubber, the muscular layer is taken off in a similar manner. The head is next removed by disarticulation at the atlas and the thorax is opened by sectioning the ribs. The entire visceral mass is removed from the carcass by attaching a cable around the upper end of the trachea and esophagus and pulling the mass from its body attachments with the winch while the flenser frees the tissues. Ribs and vertebrae are next disarticulated. Blubber, muscle, and viscera are cut into manageable fractions. Muscle is placed in a cooler at once, while blubber, fat, and skeleton are placed into proper rendering tanks. Liver and heart are likewise sectioned and cooled immediately. Muscle and liver apparently find a ready market as dog and mink food.

Following are the weights (Table 1) of various parts of the five whales taken. With exception of body weights of the first four specimens, all represent actual weight determinations. There are some regretable gaps in gland and organ weight columns. In some instances harpoon and bomb injuries made it impossible to approach an accurate weight determination. Certain gaps appear also in the adrenal weights, due to our inability to find these glands in all cases.

It will be noted that with one exception the animals are males. According to Mr. A. D. McBride of the whaling station males dominate in the catch at Fields Landing; the female finback proved an exception. Apparently these males travel singly or in small groups, for usually but a single specimen was seen or taken on a given day.

BRAIN

The most striking feature of the whale brain is its absolute size. This varied in our specimens from 5,288 to 8,325 grams (11.66 to 18.35 pounds) fresh weight, without the dura. The dura itself is unlike the dura of any other animal in our experience. It may best be described as a soft cushion varying from a thin 1/8 inch layer dorsally to a thickness of over two inches along the floor of the brain. The cushion consists of a maze of blood vessels that represent a continuation of the vast vascular sponge around the spinal cord. This spongy mass passes through the neural canal of axis and atlas, thence through the great foramen magnum and continues as the dura.

It appears that the whale brain receives the greater amount of its blood supply through this network of vessels passing upward into the neural canal, although the carotids send sizable branches, at least in the sperm whale, to the floor of the brain where an anastomosis with elements passing along the neural canal apparently takes place. No distinct circle of Willis is observable, however.

The spinal cord appears quite lost in the vascular tissue surrounding it. A

comparison of the spinal cord of whale, horse, and man taken at comparable points shows the following diameters:

	Transverse diameter	Vertical diameter
Whale	1.4 cm	1.4 cm
Man	1.8 cm	1.3 cm
Horse	2.6 cm	1.3 cm

The roots of the optic, trigeminus, vagus, and accessory nerves appear prominently on the floor of the sperm whale brain. These roots are protected by dural

TABLE 1.—*Weight data on five whales*

	HUMPBACK WHALE (*Megaptera nodosa*)	HUMPBACK WHALE (*Megaptera nodosa*)	HUMPBACK WHALE (*Megaptera nodosa*)	SPERM WHALE (*Physeter catadon*)	FINBACK WHALE (*Balaenoptera physalus*)
Sex	Male	Male	Male	Male	Female
Length	44 ft.	45 ft.	41 ft.	43 ft.	71 ft.
Body Weight	39,916 kg. 88,000 lbs.	40,823 kg. 90,000 lbs.	37,195 kg. 82,000 lbs.	39,000 kg. 86,000 lbs.	59,394 kg. 130,942 lbs.*
Adrenal	——	1.210 kg. 2.66 lbs.	——	0.350 kg. 0.77 lbs.	0.732 kg. 1.614 lbs.
Thyroid	——	2.960 kg. 6.52 lbs.	3.237 kg. 7.13 lbs.	0.800 kg. 1.76 lbs.	3.970 kg. 8.752 lbs.
Brain	6.800 kg. 15 lbs.	7.229 kg. 15.94 lbs.	5.288 kg. 11.66 lbs.	8.338 kg. 18.49 lbs.	8.325 kg. 18.353 lbs.
Kidney	——	——	192 kg. 424 lbs.	——	209 kg. 461 lbs.
Liver	363 kg. 800 lbs.	635 kg. 1400 lbs.	476 kg. 1050 lbs.	420 kg. 925 lbs.	809 kg. 1783 lbs.
Heart	181 kg. 400 lbs.	193 kg. 425 lbs.	214 kg. 472 lbs.	126 kg. 277 lbs.	382 kg. 842 lbs.
Lung	——	——	——	——	394 kg. 868 lbs.
Spleen	——	——	6.041 kg. 13.33 lbs.	——	6.800 kg. 15 lbs.
Eyes	——	0.980 kg. 2.16 lbs.	——	0.290 kg. 0.64 lbs.	1.720 kg. 3.792 lbs.

* Twenty per cent was allowed for blood and body fluids for this specimen.

sleeves extending outward some distance from the brain proper. Tributary arteries from the carotids, which enter the brain near the optic chiasma, are likewise provided with dural sheaths. One notable difference between the brain of the sperm whale and that of humpback and finback whales is the relative difference in the size of the cerebellum. In the four baleen whales the cerebellum forms an enormous mass posterior to and somewhat ventral to the cerebrum. In the sperm whale it is completely hidden by the cerebrum and in a sperm whale brain which weighed 8,388 grams in the preserved condition it had a volume less than half that in the hump and finback whales.

We evaluated the degree of cephalization of these five whales and compared

them with the porpoise and six white whales taken in earlier expeditions. By applying the power equation $y = b \cdot x^k$ (see Quiring, 1941) to this problem, it is observed that the cetacean brain follows a fundamental law of growth common to the vertebrates. By using a k-value of .54, the constant for brain weight relative to body weight, the following values were observed:

NO.	ANIMAL	SEX	b VALUE (CEPHALIZATION COEFFICIENT)	
1	Humpback	m.	1.858	Baleen whales
2	Humpback	m.	1.946	
3	Humpback	m.	1.884	
4	Finback	f.	1.831	
5	Sperm whale	m.	2.314	Toothed whales
6	White whales	m.	2.212	
7	Porpoise		2.337	

The last three groups are toothed whales and show a higher degree of cephalization as measured by this scale than do the baleen whales. This difference in cephalization between Odotontoceti and Mystacoceti appears to be significant and may possibly be correlated with differences in food habits and behavior pattern.

THYROID GLAND

The thyroid gland is about the most accessible gland of the whale's body. It lies in the usual mammalian position at the head of the trachea. The blood supply enters chiefly through superior and inferior thyroid arteries with a venous network ventral and caudal to the gland carrying the blood away. The weight of the gland varies in our specimens from 800 to 3970 grams, although it is possible that we did not secure the entire gland in the case of the smallest specimen. The lowest weight was recorded in the sperm whale, the highest in the great finback.

Histologically the gland shows an interesting structure. Great colloidal areas in stained specimens give the appearance of quiescent glands. The secreting epithelium generally shows a low columnar pattern when stained with hemotoxylin and eosin. In certain areas, chiefly near the margins of the thyroid gland, the secreting epithelial cell layers appear to be separated and blood capillaries have entered into these areas. Apparently the more minute vascularization is accomplished in this manner. This vascular pattern appears as an addition to the usual capillary distribution between adjacent follicles.

ADRENAL GLANDS

The adrenal glands are difficult to find in the whale body. In all three species of whale taken, they lie cephalad to the kidneys. By following the coeliac axis artery for a distance of three or four feet they may be located ordinarily. They

are oval-shaped in outline. In breadth they ranged from three and one-half to five and one-half inches; in length from six to nine inches. In thickness the individual glands varied from eight-tenths to one inch at the point of greatest thickness to three-eighths of an inch near the margins. The gland is covered by a tough capsule through which blood vessels and nerves penetrate; a definite hilus is not discernible. The medullary portion appears well centered in the gland. Whether a secondary capsule separates the medulla from the cortex has not as yet been determined. The innervation of the gland does not appear to be very extensive and no adrenal ganglia were noted on or near the surface of the gland. The blood supply consists of several vessels penetrating the gland at intervals.

KIDNEY

The kidneys varied in weight from 424 to 461 pounds for the two specimens that we weighed. In the other cases extensive mutilation had occurred by the

TABLE 2.—*Additional weight data on finback whale*

ORGAN	KILOGRAMS	POUNDS
Stomach	310	685
Intestine	1,009	2,255
Diaphragm	250	552
Muscle	9,863	21,780
Tongue	1,227	2,705
Fat and Muscle Bits	12,391	27,319
Blubber	11,603	25,581
Skeleton	8,913	19,651
Uterus and Oviducts	103	215
Ovaries	5.150	11.35

explosion of the bombs and hence accurate weights could not be taken. It is a lobulate type of kidney with the ureter draining the gland at its caudal end.

LIVER

The liver is the largest single gland in the body. It is tri-lobed with two large lateral and one small median lobes. A gallbladder was not found. A typical hepatic portal system is present. The gland itself is a firm consistent mass provided with a heavy connective tissue capsule. It lies well forward against the inferior surface of the diaphragm. The weight showed considerable variation ranging from 800 to 1400 pounds in animals of comparable body weight. In the 71 foot finback the liver weighed 1783 pounds.

HEART

The heart is centrally placed and exhibits the typical four-chambered mammalian pattern on external examination. The apex is greatly rounded. The ventricular walls varied from three to seven inches in thickness in the relaxed

state. At the bend of the aortic arch a definite bulb-like dilatation was observed in all the specimens. The aorta was 3/4 of an inch thick at its origin. A detailed dissection of the heart is in progress.

LUNGS

The lung is a massive organ over seven feet long in large specimens. Right and left lobes appear to be of equal size, correlated with the central position of the heart. Unfortunately the tissues were congested with blood and sea-water in all save one specimen; it was difficult therefore to secure accurate lung weights.

SPLEEN

The spleen is surprisingly small considering the great size of the animal. In view of the great variations in size of the spleen in our common animals, it is difficult to state what the normal size of this organ is in almost any form. In

TABLE 3.—*Breakdown of skeletal weights*

	KILOGRAMS	POUNDS
Total rib weight	1,276	2,814
Tail vertebra and tail fin	301	664
Scapula flukes, part of head	523	1,154
Lower jaw	762	1,680
Bone in head	1,961	4,323
Baleen	484	1,068
Vertebrae	3,605	7,948
Total	8,912	19,651

the adult horse it ranged from 3,000 to 5,000 grams. In two whale specimens it weighed 6,045 grams in a humpback and 6,800 grams in the finback.

EYES

The eye of the sperm whale is about 1/3 the weight of the finback eye. Whether this is correlated with the behavior of the animals we cannot state.

REPRODUCTIVE ORGANS

With one exception all our animals were males. The penis, housed normally in an integumental sheath, varied from five feet to eight feet four inches long in these specimens. The testes were internal and weighed 4,220 grams as compared with 18,160 grams of testes taken from a 14,640 pound elephant in our collection.

In the female finback, which was non-pregnant, uterus, ovaries, and oviducts weighed 215 pounds. The ovaries alone weighed 5,150 grams.

Tables 2 and 3 give additional weights of finback tissues. Body fat surrounding the intestinal organs was weighed separately from the blubber that was distributed outside the body cavity. The fresh skeleton freed of muscle and tissue but not dried made up 14 percent of the total weight. The tongue alone accounted for 2 percent of the body weight.

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A TECHNIQUE FOR MARKING MAMMALS

BY ARTHUR H. COOK

In any mammalian life history study, it is highly desirable to be able to mark individual mammals so that they may be identified at a later date. To meet this need, several techniques have been suggested, but none has been entirely satisfactory. The requirements of a satisfactory marking technique may be listed as follows:

1. It should not injure the pelt of fur-bearing mammals;
2. It should not increase the mortality rate;
3. It should make permanent identification possible;
4. It should be humane;
5. The identification should attract the attention of a trapper;
6. The identification should be easily and quickly applied;
7. Materials should be inexpensive.

The Erringtons (1937) proposed a method for marking young muskrats for purposes of study. In use, an aluminum tag was inserted through the skin that lies over the shoulder blades, "as here the tag would be less likely to get in the animal's way and would also be out of the reach of its teeth, if not its claws." This technique must damage the pelt to some extent, its application would be difficult if the muskrat were old enough to be aggressive, and death may result if the individual is too young to withstand the ordeal of marking. Using this method, "the optimum age for tagging seems to be between 12 and 15 days. . . ."

Bradt (1938) suggested a branding technique for marking beavers, after learning that a metal seal secured to the spatulate tail of this mammal would slough out in a few years. The method, resulting from Bradt's experimentation, resulted in the use of straight line numbers, as circular numbers " . . . were marred and obscured, due to the shedding or sloughing away of the scaly surface adjacent to the curves and angles." For this particular species, the proposal has merit in that it can be recognized at any time by the investigator. It fails, however, in that a trapper would be unable to determine, unless specifically instructed, the number of the mammal or the origin of the marks.

Aldous (1940) proposed that the webs on the rear feet of beavers could be punched, and with the use of a code, a large number of beavers could be marked. A trapper would likely overlook the punched holes, but if he did notice them, they would mean little to him. Furthermore, beavers frequently tear the webs, and if this were to follow marking, recognition marks might be obscured.

Ashbrook (1936) listed various techniques for marking wild animals such as tattooing, toe clipping, and ear tagging. Of these, the last most nearly meets

the requirements, but unfortunately, it cannot be applied to certain small-eared mammals.

The method here-in-after described seems to meet the above mentioned qualifications. This method makes use of a metal tag which encircles the Achilles' tendon (*tendo calcaneus*) (see figures 1 and 2). In use, the pointed arm of the tag is forced through the skin just in front of Achilles' tendon. Then the two arms of the tag are rotated to the rear and sealed together. Sealing is accomplished by a special tool supplied by the tag maker.

Two kinds of tags have been used during the experiment, monel metal and aluminum. The monel metal is much harder and less subject to removal by chewing. The aluminum tag, on the other hand, seems to irritate less, and as a result, the wounds made by tagging heals more rapidly when aluminum is used.

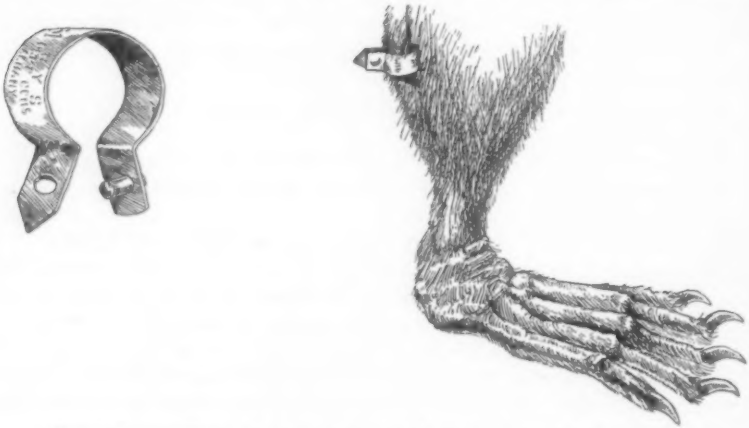

FIG. 1. LEFT.—Type of tag used; FIG. 2. RIGHT.—Attached tag encircling the tendon of Achilles.
(Sketches by E. J. Gerberg.)

To date muskrats, red and gray foxes, opossums, and skunks have been marked by this procedure. Cottontail rabbits, hares, beavers and the small rodents might also be identified in this manner. Raccoons and deer can be ear tagged more successfully.

The mammals used for experimentation lost no weight in spite of inflammation and swelling. Death occurred but once. This may be attributed to the enclosure of part of the muscle tissue within the seal.

I wish to acknowledge the helpful assistance of E. J. Haas of the National Band and Tag Company in connection with these experiments.

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NOTES ON THE MAMMALS OF SOUTH AND CENTRAL WEST BAFFIN ISLAND

BY T. H. MANNING

Special interest is attached to the fauna of central west Baffin Island owing to the absence of Eskimos on this coast from Bowman Bay northward to a camp some 50 miles north of Piling, a distance of about 300 miles in a straight line. Although it is possible that occasional spring hunting journeys have been made by Iglulik Eskimos nearly, if not quite, to Piling from 1935 on, and although a party of caribou hunting Eskimos from Pangnirtung (on Cumberland Sound, east Baffin Island) visited Taverner Bay in 1938, it is unlikely that the game has been appreciably affected. The north coast of Foxe Peninsula also has been rarely visited by Eskimos, at least in recent years. The same is true of the Lake Nettilling area, except near its eastern end. In 1937–38, Foxe Peninsula natives camped at the southern end of the lake, but during the winter of 1938–39 caribou were scarce there and the Eskimos moved to Cumberland Sound. Thus this long stretch of coast has been a natural game sanctuary for perhaps a hundred years.

Owing to the extreme flatness of the coast, there probably never have been permanent Eskimo camps between Bowman Bay and Taverner Bay; but the numerous rock structures show that the coast between there and Piling once supported a considerable population. When or why the region was deserted cannot be proved, but a failure of the caribou is the most likely reason. In the summer of 1940, Iglulik Eskimos were said to be at Piling; in the spring of 1941, some of them visited Cape Dorset to trade. Thus it appears that this coast may be inhabited once more. These natives belong mostly to the Aivilingmiut branch of the Iglulik Eskimos who moved northward from Repulse Bay about 1936 because of the growing scarcity of game. Compared with the eastern Baffin Islanders, they are primarily walrus and caribou hunters. Since walrus are nearly or completely absent from the central west Baffin coast, it is to be expected that if more than a few families make their abode there, the caribou will rapidly be exterminated from the coastal area within a few years, unless steps are taken to prevent unnecessary slaughter.

As an illustration of the waste that may occur where caribou are plentiful, I should mention that when I was away from Hantzsch River in the fall of 1938, an Eskimo killed 30 caribou within half a mile from our tent; but they were so

plentiful that he thought it unnecessary to cache them, for more could be obtained later. On my return, most of the meat had been eaten by gulls, foxes, and other animals. This is no exception.

The following accounts are based upon notes and observations made between July 1938, when we left Cape Dorset, and September 1940 when we arrived at Iglulik. In 1939 we made winter journeys from Hantzsch River to Piling, and up Hantzsch River as far as it could be traced. In 1939–40 we left Taverner Bay on December 19, and made a round trip to Cape Dorset, Cape Dorchester, Chorbak Inlet, and Pangnirtung by way of Bowman Bay and Lake Nettilling. We returned to Taverner Bay in March. On the way to Hantzsch River in 1938, we stopped for periods of one day to two weeks at Nuwata, near Cape Dorchester, 50 miles south of the Koukdjuak River, and at the Koukdjauk River. Between September 12 and 28, 1939, we made a boat trip to Wordie Bay with numerous halts on the way. We spent most of the summer of 1939 at Taverner Bay. In late July, we took one boat trip to the Koukdjuak River with landings at several places on the return journey, and another to Hantzsch River in September. We spent the summer of 1940 up to August 4 between Taverner Bay and the Koukdjuak River. On August 4, we left Taverner Bay for Iglulik, making several stops, including two of more than a week each south of Piling. North and west of there we also stopped several times, but for not more than a day. Besides those mentioned above, we made many other short trips within 30 to 40 miles of our camps at Hantzsch River and Taverner Bay.

PREVIOUS EXPLORATION

Some portions of the coast from Bowman Bay and Piling, with which this paper chiefly deals, were previously visited: Koukdjuak River to Wordie Bay in 1910–11 by Hantzsch (1913); Koukdjuak River in 1926 by Soper (1928); Bowman Bay to Hantzsch River in 1929 by Soper (1930); Bowman Bay in 1927 by the Putnam Expedition (Putnam 1928); Piling in 1937 by Bray (1928) and G. W. Rowley, and in 1939 by P. D. Baird. So far as the present paper is concerned, Hantzsch's (1913) work is the most important, as he spent about 9 months in the region under discussion. Soper's report (1928) is the only other work that deals with mammals.

TOPOGRAPHY

The greater part of Foxe Peninsula consists of low granite ridges interspersed with grassland. Toward the south coast there is less grass, and the hills rise to about 1,000 feet. A grassy plain, broken only by erratic boulders, stretches northward from Bowman Bay to Taverner Bay. From there to Piling, the land is similar to that of the northern part of Foxe Peninsula, with low ridges and grassland predominating; in a few places, hills, rising to about 300 feet, run out toward the sea. Inland, the land is rougher, with more hills and rocks and less grass. North of Piling, the country is more hilly and rocky, but Baird Peninsula, Bray, Kock, and Rowley islands and most of Munk Island are low with limestone ridges interspersed with patches of grassland. Low land also occurs north of Munk Island.

FIG. 1. Map of part of Baffin Island and adjacent areas

SPECIES ACCOUNTS

Rangifer articus (Richardson), Barren Ground Caribou

Distribution and Numbers, observed on the Central West Coast in 1938.—On our way north in 1938, the first caribou, about 12 altogether, were seen near the Koukdjuak River, but as only one previous landing had been made, there may have been some on the coast farther south. After our arrival at Hantzsch River on August 26, they were numerous and I believe that on no day did Sandy (our Eskimo) or I walk for an hour or two without seeing them.

Probably nearly 300, or about 18 a day, were seen between that date and September 12, when my wife and I left to go up the coast by boat.

Farther north the caribou were more numerous than they had been at Hantzsch River, although Sandy reported that there was a considerable increase there soon after we left. At the north end of Hantzsch Bay, caribou were rarely out of sight between September 22 and 28 and every hour a single animal or a herd numbering up to 25 passed within 150 yards of the boat. While there, we saw at least 400 and there was no decrease before we left. At no other time did we see them so fearless. During cold, calm, winter weather, caribou are difficult to approach and, contrary to Soper's observations (1928, p. 69), I should say that they are tamest in summer, but I agree with him that much depends on the individual as influenced by the weather, presence of wolves, and other factors.

I have no data for October 1–14, but Sandy, while travelling south to Chorkbak Inlet in the latter half of the month, saw no tracks until he was south of Bowman Bay. At the same time, I went 20 miles up Hantzsch River without seeing any fresh tracks. From that date, no tracks were seen in the vicinity of Hantzsch River till the following spring; occasional tracks, however, were observed just south of Wordie Bay.

1939.—During our February journey to Piling, several caribou and many tracks were seen north of Point Peters, although we seldom left the edge of the ice. The characteristic soft summer droppings showed that they had been plentiful there for at least part of the previous summer. These droppings were also observed on the Tweedsmuir Islands, although no tracks were seen.

On our journey up Hantzsch River in March, we saw no tracks for the first 15 miles; then the number gradually increased as we went farther inland. They were particularly numerous among some rough and rocky, though low, hills near the headwaters of the river. That only about 100 caribou were seen on this trip was due largely to the roughness of the country.

The first tracks near the mouth of Hantzsch River were seen about May 1 and a day or two later three does were seen. During June and July of 1939, caribou were frequently seen at the north end of Taverner Bay, although they were not so numerous as at Hantzsch River in the preceding fall. All that were observed closely enough for the sex to be distinguished were large bucks. They showed a tendency to move toward the south along the coast; this was also indicated by the tracks in the soft mud along the shore. In August caribou were numerous at the north end of Taverner Bay with a slight predominance of does. At Hantzsch Bay they seemed less plentiful than in the preceding year.

1940.—In April, caribou tracks were about as numerous east of Soper Highland as in the preceding year. On June 28, the first caribou were seen near our camp 20 miles north of the Koukdjuak River, but a little earlier several had been near the south end of Taverner Bay and about 15 miles inland along the western edge of Soper Highland. Some of those seen inland were does, including two with fawns. No does were seen on the coast south of Taverner Bay, although two with fawns were seen near the south side on July 23. At all our stops on the way to Piling between August 4 and 21, fresh caribou tracks were seen in the soft marsh and in some places herds were observed; thus, there is every reason to believe that they were about as numerous all along the coast as around Hantzsch in early September of 1938.

On the southeast shore of Baird Peninsula we saw about 80 caribou in three days. At Harbour Bay, we saw neither caribou nor summer droppings, although winter ones were numerous. There we met Eskimos and from them learned that, although no caribou were there in summer, they would be numerous later. The Hudson's Bay Company's post manager at Igloolik said that during the previous winter caribou had been numerous on the Baffin Island side of Fury and Hecla Strait.

Surrounding Areas.—We saw no caribou on Foxe Peninsula and what few tracks we did see were near Bowman Bay. A few caribou were shot by the natives to the northeast of Chorkbak Inlet. The natives say that they were once very numerous in the Nuwata district, but now they have been exterminated from all but the extreme eastern part of Foxe Peninsula (*cf.* Soper 1928, p. 67).

In February 1940, we saw no caribou tracks between Bowman Bay and Lake Nettilling; but they were numerous along the shore of the lake and several herds were seen on the lake, particularly in the region of Magnetic Point. We saw neither caribou nor their tracks on Nettilling Fjord (between Lake Nettilling and Cumberland Sound), but they were said to be fairly numerous in the Cumberland Sound area (north side?). On March 4, caribou were again numerous near Magnetic Point, but no tracks were seen near the northwestern side of the lake, or between there and Taverner Bay. All the caribou on the lake were moving northward and most of the tracks were also leading in that direction. The total number of caribou seen in the neighborhood of Lake Nettilling was about 130 in eight or nine herds, the maximum number in any herd being about 25.

Estimated Caribou Population.—In the section above I have dealt with the distribution and number of caribou at some length in order to show the evidence on which the following estimate is based.

In 1938, a daily average of 18 caribou was seen, near Hantzsch River, the area covered each day being about nine square miles. The data given above show that from the north of Taverner Bay to Piling caribou were comparatively evenly distributed during July, August and early September. Between Taverner Bay and the Koukdjuak River, caribou were perhaps only half as numerous, but there was no change in their numbers for at least 20 miles inland, while to the north of Taverner Bay I have evidence of their distribution for only 10 miles inland. In the coastal strip of 160 miles between Koukdjuak River and Piling, there were, therefore, about 3,200 caribou, with another 300 on Baird Peninsula. Inland I did not observe any diminution in the number of caribou, but beyond an average distance of 10 miles, the country becomes more rocky with a distinct decrease in the succulent marsh grasses that are one of their favored summer foods.

The area of virtual sanctuary including the Tweedsmuir Islands and Baird Peninsula, from Piling in the north to the Koukdjuak River in the south, and running 70 miles inland, measures 11,500 square miles. I suggest that in this area the summer caribou population is about 10,000. In the winter, these animals probably cover an additional area, chiefly to the northwest, of 8,000 square miles, thus occupying a total of about 20,000 square miles. This would mean an average distribution of 1 caribou to 2 square miles, including lakes and barren rocks. Judging from some winter observations, this is a very conservative estimate; indeed, since the lowest probable figures have been used throughout, it might conceivably be doubled. The northwestern end of their range has been regularly hunted by a few Eskimos for many years and wolves are rather numerous throughout, but I doubt that it would support a much larger population of caribou over a number of years, as large tracts are barren.

Migration.—Our observations of actual movement gave little satisfactory evidence of migration, but the difference in the summer and winter distribution in some areas was marked, as suggested in the following tabulation:

LOCALE	SUMMER	WINTER
West of a point between Piling and Harbour Bay.	Absent or very scarce	Plentiful
From Piling to Point Peters	Plentiful	Plentiful
From Point Peters to near north end of Hantzsch Bay	Plentiful	Scarce
Hantzsch Bay to Koukdjuak River	Plentiful	Absent
Koukdjuak River to Bowman Bay	No evidence	Absent

Soper (1928, p. 66) points out that the depth of hard-packed snow on the flat plains south of Taverner Bay makes them unsuitable for feeding grounds from November to late May. Actually, in both 1938 and 1939, the caribou had left the flat land before mid-October, long before the snow was either deep or hard-packed. Perhaps this was due to the absence of reindeer lichen and the freezing of the more succulent grasses to nearly half their height in the marsh and standing water. I know of no good reason for the absence of caribou north of Taverner Bay in winter, as both the country and the vegetation are similar to those

immediately south of Piling. North of Piling, the country is more hilly and the small amount of grassland may well account for their absence in summer.

Corporal McInnis of the R.C.M.P. (Soper, 1928 p. 68) says that large herds of caribou migrate north in the spring from Melville Peninsula across Fury and Hecla straits; on the north shore they divide for the summer, some going east, the others west. Although I believe that some animals still do cross there, I know of no record of large numbers crossing and no mention of it is made by Richardson (1825), or, so far as I am aware, by Parry (1824) or Lyon (1824). So McInnis' statement is probably a misinterpretation of an Eskimo report. It was presumably by way of Melville Peninsula, however, that caribou first arrived on Baffin Island, and one is tempted to speculate whether the movements of the east coast herds may not be a recapitulation of their ancestral migrations.

Sufficient evidence is not available to prove that a regular northwest movement of caribou takes place along the coast in the fall, but, if the movement is not northwest, it must be inland in the south, and seaward in the north. The increase of caribou around Hantzsch River, and to the north of there, toward the end of September 1938 may have been due to an early movement from the flat land before the more general movement toward the northwest began, or it may have been the culmination of a summer movement toward the coast.

Sex Segregation and Herding.—Although does and bucks were sometimes observed feeding together during the summer, they invariably acted independently when disturbed. The first true mixed herd was seen in 1938 on September 16 and on September 14 in 1939. The smaller bucks were the first to join the females and the does without fawns the first to join the males. By the end of September, most bucks and does were in mixed herds. Unless accidentally separated, fawns remained with their mothers until at least one year old; it was quite usual to see, as late as September 10, a doe with a fawn of that year and one of the year previous, presumably hers. When the mixed herds formed, the female yearlings joined them, but many of the yearling males wandered about alone, or in twos and threes. The females usually bear offspring at the end of their second year.

Near Hantzsch River, both does and bucks were found throughout the summer. Near the south end of Wordie Bay from September 12, when we arrived, until September 15, there were no females, although more than 50 males were seen. Except for two does seen on July 23, only males were on the low land at Taverner Bay, and to the south as far as the Koukdjuak, from the first arrival of the caribou until August, and even later in the southern part. The segregation of males at Wordie Bay may have been local and temporary, but at Taverner Bay the absence of does was noted both years. Accordingly it may be presumed normal and it is perhaps associated with the extremely flat and marshy nature of the country. No area was confined to the females, but they considerably outnumbered the males at the north end of Taverner Bay during mid-August. The bucks in the areas of segregation were nearly full-grown.

Coinciding with the appearance of mixed herds was an increase in the size of the herd from about 8 to 30. The two largest herds numbered a little over 40. One was seen in March about 30 miles inland, the other in late September near the coast. On September 27, 1938, about 120 caribou were seen grazing together in an area of about two square miles, but this was an aggregate of several herds that separated when disturbed. Single animals might be seen at all times, but most frequently in the summer. They were usually males.

Increase.—Most regrettably, no count was made of the relative proportion of does with and without fawns, but I should estimate that half of those over two years of age had fawns in August. The largest does were those most often without fawns. Over the whole period of observation, as many males as females were seen, but during the fall when the herds were mixed, there was a distinct preponderance of the latter. This, if general, would be sufficient to offset the yearlings, and give a 25 per cent increase, which would probably be reduced to 20 per cent by wolves or other agencies before they reached breeding age.

Shedding and Growth of Coat and Antlers, and Accumulation of Fat.—My observations on the growth of antlers were closely in accord with those of Soper (1928, pp. 70–71), although the antlers of the big males appeared to be developed rather earlier than the dates he gives.

For instance, the antlers of a large buck observed on May 25 were about two feet long, and several seen on June 6 were considerably farther advanced. It was further noticed that the young bucks resembled the does in the time of growth of the antlers and shedding of the velvet. The larger bucks began to shed their velvet one or two weeks before the females, and their antlers were usually clean by the end of September. Sometimes the velvet remains in a dried condition on the antlers of fawns until they are shed. A fawn was collected in this condition as late as April 7; the same was noted by Hantzsch (1913, p. 149).

The new coat appears later on the small males than on the large, and still later on the females. Thus, by the end of July, most of the larger bucks were almost or completely free of old hair, while the does did not reach a similar condition until the middle of August. The skins are most suitable for inside clothing immediately after the old hair has been lost and for outside clothing about two weeks later, varying somewhat with individual taste of the wearer. Hantzsch (1913, p. 146) gives the second half of August as the date at which skins are best, but undoubtedly he was referring to the females and the smaller males, as the hair and the skin of the larger bucks would then be too heavy for all but sleeping skins. This needs stressing, as there is a closed season on caribou in the Northwest Territories from March 1 to August 31. Only a few of the smaller does are suitable for inside clothing during the open season and, of course, these are the animals that should be protected. In June and early July when the coat is shed, the skin of even the largest bucks is thin and papery, but it rapidly increases in weight as the hair grows. The skins from fat animals have the strongest and softest vellum, but there might be a considerable variation in its condition in two otherwise identical skins. The reason for this was not apparent.

The individual variation in the color of the hair was especially marked among the younger animals. The full grown males were the most constant. Variation in the shape of the antlers was also considerable (*cf.* Soper, 1928, p. 72).

On June 6, the larvae of the warble fly were ready to come out of a large male and on the 13th of the same month they were out of a similar animal (*cf.* Hantzsch, 1913, p. 145). There were invariably more larvae under the skins of males than of females and more in full grown than in young animals. This may be associated either with the date on which the hair is shed, or with the relative fatness of the sexes, as the scars left by the grubs are usually near the rump, which is the fattest part. A year-old fawn may have no scars or any number up to five; large bucks usually have several hundred.

A male shot in late March was devoid of fat, and his flesh was much wasted; this condition is probably normal throughout the winter. Hantzsch (1913, p. 146) mentions that males had lost their fat by the end of October. On the large males, the fat begins to form as early as mid-July and probably reaches the maximum by September. The smaller animals of both sexes accumulate very little fat; the does with fawns are thin, but the large does without fawns may be quite fat by mid-September.

Lepus arcticus Ross, Arctic Hare

Distribution.—Hare are probably numerous all along the west Baffin coast wherever the country is sufficiently rocky and broken for them to obtain the willow shoots that constitute chief food. Hantzsch (1913, pp. 150–151) also found them fairly numerous. No hares were seen on the marshland between Bowman Bay and Taverner Bay during winter or summer, nor were any tracks seen during the winter more than six or seven miles south of the granite ridges (*cf.* Soper, 1928, p. 60).

Although there is numerical variation from time to time, perhaps irrespective of the season, such variations seem to be local and neither on Baffin nor elsewhere have I noted any pronounced cycle. Thus, in places where hares were numerous in 1933–35 on Southampton Island, they were also numerous in 1937–38; the same was noted on the north side of Frozen Straight in 1936–37 and again in 1940. On the other hand, Clarke (1938, p. 68), states that ". . . its fluctuations are surely among the most remarkable." I have never seen more than 10 hares at one time, but Freuchen (1935) saw 60 of them scattered about the hillsides near Mount Tikerarssuaq, Cockburn Land, on June 14, 1924.

Pelage.—Animals at least partially white were noted on Baffin Island as late as June 20 and as early as September 3. That noted on the latter date was a male, and white except for the head. The coat was short and looked as if it might have been worn all summer. Kumlien (1879, pp. 53–54) states that "any [hares at Cumberland Sound] do not undergo change of color during summer . . .", but he does not say whether they have a summer (spring) change of coat, or whether the new summer coat is white. Normally, the short, dark summer coat grows under the old winter one which can be removed in handfuls from the dead animal, exposing the new coat beneath. The change back to the winter coat seems to be effected differently. The females appear to lose their winter coat at least two weeks before the males.

Additional Notes.—On June 28, 1938, at Seahorse Point, Southampton Island, two young hares about four inches long were found. They were lying absolutely still on grey rock and were hardly visible. One that was picked up did not move or show any sign of fear in the hand for perhaps three minutes. Then it suddenly uttered a loud, nasal "how how how", like the cry of a duck hawk, and began to struggle. In two minutes the mother ran up at full speed to within a yard; then, seeing me, she ran off to about 20 yards. The young were taken home alive. In the tent, they appeared quite content and unafraid; they did not call again for their mother.

The mammae of a female shot at Hantzsch River on August 28, were still considerably enlarged.

There is a distinct difference in the behavior of hares according to the season. From August to January inclusive, they usually freeze motionless until approached within 20 or 30 yards. Not even in late September, when their white winter coat makes them extremely conspicuous against the still snow-free ground, will they attempt to run. From March to June, they run at the first approach of danger and, in the spring, sit on the hill tops, where they can both see and be seen from all directions.

Lemmus trimucronatus (Richardson), Brown Lemming

Only four lemmings were collected, all being of this species. From August 1938 until the spring of 1939, we saw neither lemmings nor their tracks. Then in late March, about 20 miles inland, we saw twelve tracks. The following fall we saw two or three tracks at Taverner Bay, a similar number near Lake Nettilling during a mild spell in February 1940, and a few there again in early March, although the weather was cold. In the spring of 1940, there were fairly frequent tracks at Taverner Bay and inland, but by May they were less numerous. The grassy land around Taverner Bay in some places was honeycombed with old runways, showing that in some years there must have been great numbers of lemming.

Canis lupus Linnaeus, Arctic Wolf

Distribution and Numbers.—Wolves were heard several times during the fall of 1938. A group of seven was twice seen in November about 8 miles north of Hantzsch River. They were all light colored. We continued to see tracks near there until the end of January, by which time four wolves had been trapped. Occasional tracks were seen elsewhere north of Hantzsch during the winter; in March a number of old ones were seen about 20 miles inland, and a little farther from the coast there were fresh ones. On September 17, 1939, tracks of at least 15 wolves were seen just south of Hantzsch River, but they were not seen again near there. We saw two tracks on Lake Nettilling on February 15, 1940. There was no evidence of wolves on Foxe Peninsula, on the flat land south of Taverner Bay, or to the south of there, in either summer or winter. The observations of both Hantzsch (1913) and Soper (1928) are in general agreement with those given above. There seems, therefore, to be some wolves not far from wherever caribou are numerous except in the flat land; there the lack of cover and the soft marsh would put the wolves at a disadvantage. Packs of more than 10 are rare.

In the 20,000 square miles of west Baffin, for which a caribou population of 10,000 was estimated, there are, on a conservative estimate, 150 to 200 wolves, or fewer than one wolf to 100 square miles. This is only one-sixth of N. H. Harmon's estimate (Clark, 1938, p. 108) for the caribou district on the mainland, but, owing to the difference in the density of the

caribou population, the proportion of wolves to caribou would be slightly greater. This is natural in an area where man's effect has been small.

Effect on the Caribou.—One wolf caught at Hantzsch River was thin; the others, which probably belonged to the same group, were fat, two especially so. Although troublesome, the wolves did not rob an appreciable amount from our caches, so, since there were no signs of lemming or ptarmigan, their food must have been caribou or hare, and I rather doubt the ability of wolves to catch many of the latter. A dog doing an ordinary amount of work needs one medium-sized caribou every 25 days to keep him in good condition; a wolf from its larger size might be expected to need one every 20 days, or, allowing for some extra food in the summer months, 15 caribou a year. This should be sufficient to keep a wolf in good condition. Many being thin, Clarke's estimate (1938, p. 109) of 11 caribou killed each year by one wolf is probably correct, if only those that reach breeding age are included. There is, however, so little meat on the fawns that should three or four be killed annually (and the weathered skulls of small caribou were rather numerous) it would bring the total back to 15. Also, some carcasses may be partly devoured by foxes and wolverines when permanently or temporarily abandoned by the wolves. On this basis, I should estimate that 2,000 caribou over one year old are killed annually by wolves in the area under discussion. This is just the number I estimated to reach that age, but probably the total caribou population was underestimated. Clarke (1938, pp. 103, 109) considers that on the mainland the wolves account for a little more than half of the yearly increase of caribou. Although wolves may under normal conditions kill a number of caribou about equal to the annual increase, if, as seems probable, they are only able to kill the old and defective animals and a few young or lost fawns, they will not prevent an area carrying the maximum population for which food is available.

Color of the Fur.—All the specimens taken were white on the flanks and belly. One had red guard hairs down the back, another, black, and one was white all over except for grayish underfur. Only one dark wolf was seen. This was a rather dark yellowish-red, but was considerably lighter below.

Alopex lagopus innuitus (Merriam), Arctic Fox

In both 1938 and 1939 foxes were very numerous until the beginning of November when there was a marked decrease in the number of tracks, especially south of Hantzsch River. Hantzsch's notes (1913, pp. 153–155) indicate a similar decrease, which he ascribed to the absence of ptarmigan and lemming. Even in the fall of 1938 and 1939 when foxes were numerous, lemmings were extremely scarce and ptarmigan not common. As at other places, some foxes probably go out on the pack ice, but I think a number also follow the caribou for the sake of the carcasses left by the wolves. We saw no tracks on the flat land between Taverner Bay and Bowman Bay in 1939, but such a condition might not hold in a good lemming year.

Some traders consider that the encouragement given to trapping by the recent establishment of trading posts in North Baffin, Melville Peninsula, and North Somerset Island will reduce the catch in South Baffin; but at present the extent to which foxes migrate is a very debatable point that can only be settled by organized marking.

There is sometimes speculation as to the relationship between a disease that periodically kills three-fourths of the Eskimo dogs and the fluctuation of the fox population, but in the two instances given below, there was no connection. The most serious dog epidemic I have seen was in the spring of 1934 (Manning, 1936, p. 235) on Southampton Island. This was definitely carried from the mainland by visiting dog teams, and the fox catch on the island was above average both during the preceding and following winters. In the winter of 1936–37, there was no dog disease on the island, but although foxes were plentiful in the early fall, the winter's catch was poor, apparently owing to a sickness among them just before the trapping season. There was no serious dog disease on the island between 1934 and 1941. The winter 1937-38 was a very good fox season there.

Mustela arctica semplei Sutton and Hamilton, Eastern Arctic Weasel

During the winter of 1938–39, weasels were extremely numerous between Taverner Bay and Piling; they were also said to be numerous on Foxe Peninsula that year. But in the winter of 1939–40, we did not see a track anywhere. I have noticed on Southampton Island that the maximum and minimum points of the weasel cycle are much more sharply marked than those of the fox cycle and the increase and decrease are more rapid.

As lemmings and ptarmigan were very scarce in the winter of 1938–39, the weasels must either have killed hares or existed by scavaging. I have only once seen the marks where a scuffle had occurred between a weasel and a hare. Then, the hare had escaped, at least temporarily. Sometimes weasels, after having lived in a meat cache for two or three weeks, disappear, presumably moving, although there is ample meat left. This indicates that they have no difficulty in obtaining food. Weasels live in holes among the rocks and it is therefore unlikely that many would ever be found between Taverner Bay and Bowman Bay.

Gulo luscus (Linnaeus), Wolverine

Freuchen (1935, p. 100) remarks that according to the Eskimos there were no wolverine on Baffin Island "20 years ago," but that they have crossed Fury and Hecla Strait in recent times and bred in large numbers. Hantzsch makes no mention of them. Kumlien (1879, p. 53) states that "There are stories of some kind of animal that from the descriptions given by some [Eskimo of Cumberland Sound] may be *Gulo*, but others say it is only the common dog." Soper (1928, pp. 32–33) says that a skin of one was traded at Pond Inlet (northwest of Baffin Island) and that another animal was killed at Cumberland Sound in the same year. Soper himself saw a track at the south end of Amadjuak Lake in 1936. Anderson (1935, p. 88) was informed that wolverines were fairly common around Pond Inlet and that three were traded there in 1927–28. In 1938, wolverine tracks were frequent from 10 miles south of Hantzsch River northward to Wordie Bay, particularly in the fall. Although always single, they were more numerous than the wolf tracks. In February 1939, we saw a track near Piling and one on the Tweedsmuir Islands. We saw no tracks elsewhere on Baffin Island. Five specimens were taken in traps, which they avoided with no more sagacity than the white fox. This is so different from the usual description of their behavior, that it indicates lack of experience with man and traps. The Eskimos say that they are great wanderers (*cf.* Freuchen, 1935, p. 100). The specimens taken were in good condition, but without fat. The hair was clean and free of grease, so it is unlikely that they were attracted by the carcass of any marine animal. We found no wolverine in 1939 after March, and none in the winter of 1939–40. Possibly this was associated with the absence of weasels.

In mild weather, a fox will often escape from a trap by breaking off its leg; wolves, if caught by a single toe, by leaving the toe behind; but I caught two wolverines alive and one dead held only by a toe. Several broke the rather small traps that were used, or at least twice the number would have been caught.

Thalarctos maritimus (Phipps), Polar Bear

Only nine bears, including two cubs, were seen; they were distributed between Baird Peninsula and Taverner Bay. There was also one track in the mud south of the Koukdjuak River. Bears are not very common around the coast of Foxe Peninsula, although in most years seven or eight are killed near Cape Dorchester. Hantzsch (1913, p. 155) saw only two tracks on the west coast, and Soper (1928, pp. 29–31) does not mention any. As bears are also scarce on the west side of Foxe Basin, their abundance on the north-east coast of Southampton Island is surprising, particularly as both species of seals were found to be rather scarce there.

Delphinapterus leucas (Pallas), White Whale

A school of white whales was seen in Taverner Bay on August 3, 1939, and in late July 1940. They were not seen elsewhere on the west coast.

Grampus orca Linnaeus, Killer Whale

About two miles from land a little north of Hantzsch River, we observed, for more than a quarter of an hour, two black, triangular objects that moved parallel with the shore, diving occasionally. They could hardly be other than the fins of killer whales, although I know of no other record from Foxe Basin. They are not uncommon in Hudson Strait, but I know of no occurrence in Hudson's Bay.

Phoca hispida Schreber, Ringed Seal

Distribution (*summer*).—Ringed seals were scarce in the sea bordering the flat land. Elsewhere they were neither particularly numerous nor scarce. Most were seen between Taverner Bay and Hantzsch River. One seal seen about 2 miles up the Koukdjuak River probably belonged to this species. (*Winter*).—The extreme roughness of the ice from Bowman Bay to Parry Point prevented winter observations. Hantzsch (1913, pp. 158–159) found ringed seals rather scarce after November, both at the floe and under the ice. He gives the lack of smooth ice as the reason for their scarcity in the latter place. (*Spring*).—There is no ice sufficiently smooth for the seals to bask on between Bowman Bay and Hantzsch Bay. At the latter place, they were first seen on the ice on April 17; some had probably been up earlier. From then until May 26, we never saw more than 15 together on the 12 square miles of smooth ice in the bay. There probably would have been more later. Fewer seals were there in 1940, but it is doubtful if the decrease was due to the hunting carried on the previous spring. The very small amount of smooth ice between Bowman Bay and Wordie Bay may cause seals to migrate north in the winter, especially those females that will be pupping in the spring. Probably large numbers of seals would be found on the smooth ice of Wordie Bay, Clarke Sound, and Piling Bay.

Size.—The average estimated weight of the 25 seals shot in the neighborhood of Hantzsch Bay was well over 100 pounds. Hantzsch (1913, p. 158) also remarks on the large size of the seals in Foxe Basin. Probably, however, they are no larger than seals at other places where they are rarely hunted. There is marked variation in size even in sexually mature individuals; but there does not appear to be a great difference in the size of the sexes. For the most part, the first seals to come up on the ice in the spring are large, and the females outnumber the males. The silver jars (*i.e.*, the young of the year) are rarely seen on the ice before June. The seals on the ice in the fall are also very large and the flesh of some of the males is then particularly strong.

Food.—Dunbar (1941, p. 150) shows that the food of ringed seals consists almost entirely of plancktonic crustacea, at least throughout the summer months. My observations, although casual, bear this out for all months of the year. Presumably, however, those seals living in Lake Nettilling must eat fish, which, according to statements made by Eskimos to Hantzsch (1913, p. 159), is the case.

The stomachs of seals shot on the ice in the spring (May and June) are usually empty, and the noticeable reduction of their fat during the month of May suggests a period of partial fasting. In September, and probably also in August, their stomachs are bulging with small shrimps, so that the condition of seals in September described by Dunbar (1941, p. 152–153) at Clyde Inlet (N. E. Baffin Island) is either an exception or confined to those seals living in deep inlets as opposed to the more open bays.

Between the beginning of June and the end of August most of the larger seals sink if shot. It is unlikely that there is much difference between the salinity of the water in August and September, but the period during which seals will sink roughly coincides with the time they are at their thinnest. I think, therefore, that they sink owing to their thinness and not to the reduced salinity of the water as suggested by Stefansson (1921, p. 196), although this may have a contributing effect which would be of importance only when the fresh water had not had an opportunity to become thoroughly mixed, as, for instance, in long inlets, and even in more open bays in calm weather, as well as amongst pack ice.

Erignathus barbatus (Erxleben), Bearded Seal

In summer, bearded seals were more numerous between Bowman Bay and Wordie Bay than on any other similar length of coast with which I am familiar (*i.e.* west Hudson Bay, west Foxe Basin, and the sea surrounding Southampton Island). They were most numerous between the Koukdjuak and Hantzsch rivers, and sometimes on fine days, three or four heads could be counted simultaneously. Along the flat coast they outnumbered the ringed seals and were sometimes seen in as little as four feet of water. Between the end of July and the middle of September eight in all were shot. The stomachs of all were almost empty except for parasites. They were all large and quite fat; each yielded about 13 gallons of blubber. None were seen during the winter as the floe was rarely visited, but Hantzsch (1913, p. 156) says they were "observed rather commonly at our winter camp", which was a little north of Hantzsch River.

Odobenus rosmarus (Linnaeus) Atlantic Walrus

Although we saw no walruses from the time we left Cape Dorset in 1938 until we arrived in Frozen Strait in 1940 after sailing around the northern shore of Fox Basin, they are in some seasons, particularly in the spring and fall, very numerous around Igloolik Island. Our failure to see any there in 1940 was probably due to the exceptional absence of ice. Walruses are often common in the neighborhood of Cape Dorchester and in 1938 the Eskimos there had obtained a number nearly sufficient for their winter dog food as early as mid-July. In the winter of 1939–40 also they were well supplied. There appears to be no reason why walruses should not occur on the Baffin coast between these districts, but there is no record of such occurrence.

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THE WILD AND COMMENSAL STOCKS OF THE HOUSE MOUSE, *MUS MUSCULUS* LINNAEUS

BY ERNST SCHWARZ AND HENRIETTE K. SCHWARZ

Since 1935 the authors have been engaged in a study of the mice belonging to the species *Mus musculus* Linnaeus. Between 4,000 and 5,000 specimens have been examined in the British Museum (Natural History), London; the U. S. National Museum, and the collection of the U. S. Biological Surveys, Washington, D.C.; the American Museum of Natural History, New York; and the Museum of Comparative Zoology at Harvard College, Cambridge, Mass. The facilities afforded by the divisional heads of these institutions are gratefully acknowledged. A small number of specimens from Ireland was loaned by Dr. E. O'Mahony, Dublin, and from northern Germany by Dr. K. Zimmermann, Berlin. Material bred in the genetics laboratory, both skins and living animals, was made available by Dr. L. C. Dunn, of Columbia University, New York; Dr. L. R. Dice, of the University of Michigan, Ann Arbor; and Dr. E. Caspari, of Lafayette College, Easton, Pa. A comprehensive manuscript dealing with this material had been ready for a considerable time, but it was not possible to have it published under the present conditions. A condensed account of the principal results is given in this paper.

In the wild stock, four different types of the species *Mus musculus* Linnaeus are distinguished. These are: *M.m.wagneri* Eversmann, *M.m.spicilegus* Petényi, *M.m.manchu* Thomas, and *M.m.spretus* Lataste.

M.m. spretus is known in the wild stage only. The other three have developed commensals which are in some way connected with human habitation and cultivation, which follow the migration of man, but under suitable conditions may become feral and return to more or less wild habits.

Characters common to all the wild forms are medium size and a tail always shorter than the length of the head and body. In all of them the lower side is white, with or without dark underfur and there is a distinct line of demarcation between the upper and lower sides.

In the commensals, certain trends of evolution are found that are common to all of them. The first is an elongation of the tail, which in many instances

becomes much longer than the head and body. A change of pattern, best described in terms of the various alleles of the agouti factor, is also of general occurrence; the pattern of the commensals corresponds to alleles of this series more recessive than those found in the wild types. In the third instance there is an increase of intensity in the phaeomelanin; here as well more recessive, *i.e.* richer, shades are found in the commensals than in the wild forms. Finally the skull of the commensal shows the well known changes characteristic of captive and of domestic mammals, *i.e.* a reduction in bulk of the face, and of the size of the molar teeth; in certain highly advanced types there is a tendency to have the molar series shortened by the suppression of the last molars.

A considerable range of variation in size is found in the commensals. This, however, is not necessarily a commensal character. Variation in the amount of black is controlled in two ways. The most advanced commensals carry the most recessive allele of the agouti factor and, therefore, are darker than the less specialized commensals and the corresponding wild types. There occurs a second type of variation in the amount of black, however. This increased black is known to be dominant (Zimmermann, 1935, and *in litteris*); its variation is not connected with commensalism. In the *wagneri* series, it occurs as an individual mutation, and also in localized populations ("*poschiavinus*", "*subcoeruleus*", "*jalapae*", "*percnonotus*"). It is found as an alternative phase (mutation) in the wild and commensal populations of the *manchu* stock.

METHOD OF QUOTATION

In order to avoid repetition in the quotation of synonyms, full references are given only for the names published after 1941, or not to be found in the comprehensive lists published by Trouessart (1897), Miller (1912), and Ellerman (1941). Full titles of these books are given under literature cited. They are all easily available. Titles of all the papers quoted in the text are given in full.

Group of Mus musculus wagneri Eversmann

WILD FORM

1. *Mus musculus wagneri* Eversmann (1848).

Mus Wagneri Eversmann, Bull. Soc. Nat. Moscou, vol. 1, p. 191, 1848.

Synonyms.—*major* Severtzow (1873), *tokmak* Severtzow (1873), *pachycercus* Blanford (1875), *bicolor* Tichomirov and Korcagin (1889), *gansuensis* Satunin (1902), *mongolium* Thomas (1908), *severtzowi* Kashkarov (1922), *oxyrrhinus* Kashkarov (1922), *decolor* Argyropulo (1933), *bieni* Young (1934).

Type locality.—Kamysh-Samarian lakes, between the lower Volga and Ural rivers, southeastern Russia.

Distribution.—Dry area of Central Asia from the east bank of the Volga River to the Yellow Sea, north to about 42–44° N. Lat. (northernmost record: Bogdo Ola Mountains, S.E. Zungaria [Carruthers]), south to about 38–36° N. Lat. (southernmost record: Turbat-i-Haidari, Khorassan, N.E. Iran [Watson]).

Color.—Back buff, or ochraceous, evenly grizzled with black; belly white with ("white belly"), or without ("snowy belly"), slaty underfur; line of demarcation sharp, a yellow flank line usually indicated; tail distinctly bicolored, never black; feet perfectly white; ears pale. Ochraceous ground color, and absence of dark underfur are less frequent, although such types may be prevalent locally. Ochraceous ground color is prevalent in Russian Turkestan, but is not found in Semirechye (Kasakstan).

Dimensions.—Head and body (in mm.): males, maximum 89, optimum (from variation curve) 75–80; females, maximum 94, optimum 80–85. Tail-ratio ($\frac{\text{head and body}}{\text{tail}} \times 100$): Variation, males 167–100, females 164–100. The optimum for tail-ratio varies in different populations. In Western (Russian) Turkestan the optimum for males is 125–130, for females 120–125. It is similar in central China (Kansu, Shensi, Shansi) where it is 130–135 for males, and 120–125 for females. In both these populations the optimum is greater in the females than it is in the males. In the populations from Chinese Turkestan (Sinkiang), and the Mongolian plateau (Kalgan), the optimum for the females is less than that for the males. Optimum for Sinkiang, males 120–125, females 120–130; for Kalgan, males 135–140, females 145–150, and 160–165. Intermediate conditions are found north of the Tienshan mountains (Semirechye). The shortest tails are found in Mongolia, central China, Semirechye, and Chinese Turkestan, the longest in Russian Turkestan, where the tail length may equal (never exceed) that of the head and body.

HISTORY OF A LABORATORY STRAIN OF *M. m. wagneri* EVERSMANN

A strain commonly used at present in genetic laboratories and supplied for medical experimental work elsewhere has been identified as *M. bactrianus* Blyth by G. M. Allen. Originally it was imported, in 1926, from near Peking, China, by Sheo Nan Cheer and kept at the University of Michigan, Ann Arbor, in Dr. C. C. Little's laboratory (Green, 1930). On arrival it consisted of four males and four females, which are the ancestors of this strain. These mice were pale sandy, had a white belly, and short tail. By their characters, as well as by the locality from which they came, they cannot be anything but *M. m. wagneri* Eversmann. It seems necessary to draw attention to this fact, as *M. m. wagneri* is a wild form, whereas *M. m. bactrianus* Blyth is a commensal, and differs in several characters from the wild stock. Through the kindness of Dr. L. R. Dice we have been able to see specimens of the mice bred from the Peking material.

COMMENSALS

2. *Mus musculus bactrianus* Blyth (1846).

Mus bactrianus Blyth, Jour. As. Soc. Bengal, vol. 15, p. 140, 1846.

Synonyms.—*gerbillinus* Blyth (1853), *theobaldi* Blyth (1853), *gentilulus* Thomas (1919).

Type locality.—Kandahar, Afghanistan.

Distribution.—Greater part of the Iranian plateau, east of Shiraz, but not in the extreme northwest. In southwestern Persia grading into *M. m. praetextus* Brants; in northwestern India found outside houses in the whole of the Indus Valley and the Punjab, but apparently only west of the lower Indus, not east of the Punjab proper; grading into *M. m. homourus* Hodgson in the northeast part of its range. In the plains of northwestern India, it develops an indoor commensal, *M. m. tytleri* Blyth.

Color.—Black ochraceous, evenly grizzled with black; belly white with ("white"), or without ("snowy") slaty underfur; line of demarcation sharp, a yellow flank line usually very distinct; tail pale, distinctly bicolored, with the tip blackish above; feet perfectly white; ears pale.

Snowy belly (no dark underfur) is prevalent in specimens from Persia, Afghanistan, Baluchistan, and Sind. White belly (dark underfur) prevails in material from the Punjab. In the greater part of its range, this animal is found in a feral condition and also in houses as a true commensal. In the indoor population, there is a tendency to develop the more recessive mutant with buffy belly, with dark metatarsals and metacarpals, not, or rarely, found in the outdoor population.

Dimensions.—Head and body: males, maximum 87, optimum 70–75 (Shiraz), 65–70 (Baluchistan, Sind, Punjab); females, maximum 78, optimum 75–80. Tail-ratio: males, variation 118–77, optimum 85–90, (Shiraz, Baluchistan, Sind), 90–95 (Punjab); females, variation 115–70, optimum 85–90 (Baluchistan, Sind), 90–95 (Shiraz, Punjab).

Differential diagnosis.—As a population, *M. m. bactrianus* is smaller (optimum for head and body, males 65–70 and 70–75, females 75–80) than *wagneri* (males 75–80), females 80–85).

The tail is longer (males 85–90, 90–95, females 85–90, 90–95) than the head and body. In *wagneri*, the tail-ratio is never below 100, and goes up to 165, which means that in *wagneri* the tail length is almost constantly shorter, in many cases very much shorter, and never longer than the length of the head and body. The ground color in *bactrianus* is always ochraceous, with the buffy mutant found in *wagneri* completely absent.

3. *Mus musculus homourus* Hodgson (1845).

Mus homoourus Hodgson, Ann. Mag. Nat. Hist., ser. 1, vol. 15, p. 268, 1845.

Synonyms.—*nipalensis* Hodgson (nom. nud.) (1841), *darjilingensis* Hodgson (1849). *kakhyenensis* Anderson (1878), *caroli* Bonhote (1902), *ouwensi* Kloss (1921), *formosanus* Kuroda (1925), *tantillus* G. M. Allen (1927), *taiwanus* Horikawa (1929), *boninensis* Kuroda (1930).

Type locality.—Central Nepal.

Distribution.—Southern slope of the Himalayan range, grading into *M. m. bactrianus* in the west near the Indus River, going up to altitudes of 10,000 feet. Eastern range extending into Burma, Siam, northern Indochina, and southern China, about as far north as the Tsinlin range. It occurs on the islands of the Riu-Kiu group, but is not found in Japan proper. Isolated populations of this type are known from the Nilgiri mountains in southern India, and from Java (*"ouwensi"*); an outdoor type.

Color.—Back tawny or cinnamon, grizzled or suffused with black; belly white or slightly buffy, with slaty underfur; line of demarcation usually distinct, with a yellow flank line present; tail bicolored, rather dark above, frequently with black tip; feet completely white, or with the metacarpals and metatarsals buffy brown; ears pale brown.

Dimensions.—Size variable according to locality. Head and body: maximum: males, 99; females, 103 (Ladak): males, 80; females, 83 (Sikkim): males, 69; females, 70 (Bhutan Duars). Optimum: males, 70–75; females 80–85 (Ladak): males, 70–75; females, 60–65, 75–80 (Sikkim): males, 55–60; females, 55–60 (Bhutan Duars). Tail-ratio: optimum: males, 85–90, 95–100; females 90–95. These figures for tail length are constant for all populations of *homourus*.

Differential diagnosis.—*M. m. homourus* is a highly variable form, variation being both individual and local. Except in the west where it grades into *bactrianus*, where ochraceous ground color occurs, *homourus* is distinguished from *bactrianus* by the ground color being tawny or cinnamon. As a population it differs from *bactrianus* also by the absence of the mutant without dark underfur on the belly and by the occurrence in the population of individuals with a greater amount of black on the back.

4. *Mus musculus tytleri* Blyth (1859).

Mus Tytleri Blyth, Jour. As. Soc. Bengal, vol. 28, pt. 2, p. 296, 1859.

Type locality.—Dehra Dun, Himalayan Terai, United Provinces, India.

Distribution.—Western half of the Indian plains, east of the Indus River, grading into *M. m. urbanus* further east; an indoor type.

Color.—Back tawny, evenly grizzled with black; belly ochraceous, with the underfur slaty; line of demarcation indistinct; tail fairly pale, particularly below, darker above, blackish towards the tip, not distinctly bicolored; feet as far as, and including, the metacarpals and metatarsals, ochraceous buff, toes white; ears brown.

Dimensions.—Head and body: maximum; males, 97; females, 106; optimum for both sexes 75–80. Tail-ratio: variable; variation, males, 104–91; females, 105–90; optimum, males, 75–80 (Palanpur), 80–85 and 90–95 (Gwalior), 95–100 (Punjab, Rohilkhand); females, 85–90 (Palanpur), 90–95 (Gwalior), 100–105 (Punjab, Rohilkhand).

Differential diagnosis.—Distinguished from *M. m. bactrianus* by the ground color, which is tawny instead of ochraceous; by the color of the belly, which is ochraceous-tawny instead of white; by the absence of distinct demarcation between the back and the belly; and by the absence of sexual differentiation in size, whereas in *bactrianus* the males average distinctly smaller than the females.

5. *Mus musculus urbanus* Hodgson (1845).

Mus urbanus Hodgson, Ann. Mag. Nat. Hist., ser. 1, vol. 15, p. 269, 1845.

Synonyms.—dubius Hodgson (1845), *viculorum* Anderson (1878).

Type locality.—Katmandu, Nepal.

Distribution.—Eastern part of the Himalayan slope and of the plains of northern India; southwestern China, *viz.* the provinces of Yunnan, Szechwan, and Kweichow, becoming less common towards the Pacific coast where its range overlaps with that of *M. m. castaneus*; does not occur north of the Tsinlin range; an indoor type.

Color.—Back tawny or cinnamon, suffused with black, or with increased black superposed; belly ochraceous, tawny or bluish grey, with dark wool, and with the individual hairs not, or scarcely, banded; line of demarcation indistinct; tail not distinctly bicolored, but paler underneath near the root; feet buffy or drab, as far as, and including, the metacarpals and metatarsals, toes white; ears dark brown.

Dimensions.—Head and body: maximum: males, 84; females, 87; optimum: males, 65–70; females, 70–75. Tail-ratio: optimum 75–80 for both sexes.

Differential diagnosis.—*M. m. urbanus* is distinguished from *M. m. tytleri* by its smaller size. In color it differs as a population, not individually. The pale type is identical with *tytleri*; the dark type differs in being not suffused with black, but with increased black superposed, *i.e.* blackened above, and bluish grey, not ochraceous, below; the reddish type differs from *tytleri* in being cinnamon, instead of tawny. In size *urbanus* is smaller than *tytleri*, particularly the male. There is a slight sexual difference in size in *urbanus* not found in *tytleri*. From the outdoor form *M. m. homourus*, *M. m. urbanus* differs by slightly larger size, distinctly longer tail, by ochraceous, tawny, or bluish grey, not white, belly, and the absence of a distinct line of demarcation along the flanks.

Segregation between *homourus* and *urbanus* is not always complete, and interbreeding occurs.

6. *Mus musculus castaneus* Waterhouse (1843).

Mus castaneus Waterhouse, Ann. Mag. Nat. Hist. ser. 1, vol. 12, p. 134.

Synonyms.—manei Gray (1843), *rama* Blyth (1865), *taitiensis* Zelebor, (1868), *albertisii* Peters and Doria (1881), *commissarius* Mearns (1905), *canacorum* Revilliod (1914), *momiyamai* Kuroda (19207, *sinicus* Cabrera (1922), *mystacinus* Mohr (1923), *dunckeri* Mohr (1923), *frederici* Sody (1933), *mohri* Ellerman (1941).

Type locality.—Philippine Islands.

Distribution.—Plateau of the Indian peninsula, Ceylon, Assam, Burma, Siam, Malay Peninsula, and coastal area of southeastern China, as far as the Yangtse River. No record so far from Indochina. Also found all over the islands of the Malay archipelago, New Guinea, and Polynesia, as far as the Marquesas group but not on the Australian mainland. Not found in Hawaii. Occurring in the islands of the Indian Ocean (Keeling) and on the coast of East Africa, its range overlaps with that of *bactrianus* in Somaliland and southwestern Arabia (*"gentilulus"*). All the house mice of Southeast Africa, Union of South Africa, and Southwest Africa belong here; an indoor type.

Color.—Back cinnamon or tawny, overlaid or suffused with black, or with increased black superposed; belly ochraceous or tawny, the individual hairs distinctly banded with black; no line of demarcation; tail not bicolored, in the dark phase almost black, in the cinnamon phase cinnamon above, slightly paler below, with the tip all-black; feet sepia, drab, or cinnamon, with only the end phalanges white; ears brown or dark brown.

Dimensions.—Head and body in tropical specimen have an optimal size of 70–75 for both sexes. In the Kathiawar peninsula the females average slightly less, in Assam slightly more, than the males. Mice from Australia and Africa are larger, and with increasing distance from the Equator considerably more so. Tail-ratio: Tropical specimens have a very long tail, with an optimum of 85–90 in most cases. South African specimens have shorter tails; slight sexual differences in tail length, with shorter tails in the females, are found in the Kathiawar and Assam series.

Differential diagnosis.—Compared with *M. m. urbanus*, this form is distinguished by the speckled belly and by the feet having only the end phalanges, instead of the whole of the toes, white. There is also a slightly more dusky tinge on the back, noticeable both in the lighter and in the darker types.

7. *Mus musculus praetextus* Brants (1827).

Mus praetextus Brants, Muizen, p. 125, 1827.

Synonyms.—gentilis Brants (1927), *rebudia* Loche (1867), *pallescens* Heuglin (1877), *candidus* Laurent (1937).

Type locality.—Syria, (Berlin Museum no. 1637).

Distribution.—Western Iran, Iraq, northern Arabia, Syria, Palestine, North Africa, Abyssinian coast, and Nile valley as far as Khartoum; not in the Nile delta. Also found on the islands of Cyprus and Rhodes; primarily an outdoor type.

Color.—Back ochraceous, evenly grizzled with black; belly white with ("white"), or without ("snowy"), dark underfur; line of demarcation distinct and as a rule a conspicuous ochraceous line along the flanks; tail pale, distinctly bicolored, with the tip tending to be black; feet perfectly white; ears pale.

Dimensions.—Head and body: maximum: males, 95; females, 91; optimum, 70–75, 75–80, 80–85, for both sexes; the smaller types prevail in the populations from eastern North Africa. Tail-ratio: variation, males, 134–80; females, 137–83; optimum 95–100 for both sexes.

Differential diagnosis.—Differs from *M. m. wagneri* as a population in having the ground color always ochraceous, the buffy phase being absent, and in the absence of sexual differentiation in size. West Mediterranean populations are much larger, with longer tails.

Distinguished from *M. m. bactrianus* by larger size. In Iran where the areas of *wagneri*, *bactrianus*, and *praetextus* meet, the three grade into one another.

8. *Mus musculus orientalis* Cretzschmar (1826).

Mus orientalis Cretzschmar, Atlas Reis. noerd. Afr. p. 76, 1826.

Synonym.—vignaudii Prévost and Des Murs (1845).

Type locality.—Egypt.

Distribution.—Delta of the river Nile, lower Egypt.

Color.—Back ochraceous, with increased black superposed; belly whitish buffy, or buffy, with slaty underfur; line of demarcation rather distinct, always with a conspicuous yellow flank line; tail bicolored, sepia above, with the tip black, below white; feet perfectly white, or with the metacarpals and metatarsals brownish, and the fingers and toes white; ears dark brown.

Dimensions.—Identical with those of the population of *praetextus* from the same general area, which has an optimal length of head and body of 70–75, and 80–85 for the males, and 75–80 for the females, and a tail length with an optimal ratio of 100–105 for both sexes.

Differential diagnosis.—Distinguished from *praetextus* in having the back suffused, instead of grizzled, with black, and with additional black superposed; also, with the lower surface whitish buffy, instead of white. Whereas populations of *praetextus* are more or less uniform in color, *orientalis* represents a mixed population with the dark typical *orientalis* prevalent, but with the light *praetextus* type occurring within the population, apparently irrespective of indoor or outdoor habitat. More material is necessary to settle this point.

9. *Mus musculus brevirostris* Waterhouse (1837).

Mus brevirostris Waterhouse, Proc. Zool. Soc. London, p. 19, 1837.

Synonyms.—abbottii Waterhouse (1837), *parvulus* Tschudi (1844), *azoricus* Schinz (1845), *mollissimus* Dehne (1855), *nattereri* Fitzinger (1867), *lundii* Fitzinger (1867), *flavescens* Barrett-Hamilton (1896) (nec Fischer, 1872), *jalapae* Allen and Chapman (1897), *caoccii* Krausse (1920), *far* Cabrera (1921), *percnonotus* Moulthrop (1942).

Type locality.—Maldonado, Uruguay.

Distribution.—Italian peninsula, Mediterranean coast of France, and Iberian peninsula, in the main south of the central mountain range, overlapping with *M. m. domesticus* which

is found in northern Spain; Mediterranean islands as far east as Crete. Not found in northern Spain, in the western part, and in the south of the Balkan peninsula, and in the Egean Islands. Introduced into Asia Minor, some of the Ionian Islands, and the coastal towns of north and northwest Africa. Introduced into the Azores, Madeira, Salvages, and Canary groups of islands, into South and Central America, and the southern part of the United States where its range passes into and overlaps with that of *M. m. domesticus*.

Color.—Back ochraceous, suffused with black; belly buffy white, or buffy, without speckling, and with slaty underfur; line of demarcation indistinct, with yellow flank zone usually present; tail brownish with black tip, not distinctly bicolored, but paler on the underside, near the root; feet with the metacarpals and metatarsals buffy or drab, and the fingers and toes white; ears pale brown. A dark mutant with black superposed occurs locally (*"jalapae"*, type specimen of *"azoricus"*).

Dimensions.—No pronounced sexual difference in size. Head and body: maximum: males, 91; females, 92; optimum 75–80 for both sexes. Tail-ratio: optimum 95–100 for both sexes; shorter, *i.e.* 100–105, in the Canary and Salvages, and longer (90–95) in the Azores group of islands.

Differential diagnosis.—Distinguished from *praetextus* primarily by the beginning obliteration of the color contrast between the upper and lower sides, *i.e.* by the line of demarcation being indistinct, by the back being suffused, not merely grizzled, with black, and the belly buffy, or buffy white, instead of pure white, the tail not distinctly bicolored, and the feet darkened in the metacarpal and metatarsal zones, instead of being all white.

Distinguished from its Indian homologues, *M. m. tytleri*, and *M. m. urbanus*, by the ground color being ochraceous, instead of tawny, or cinnamon.

10. *Mus musculus domesticus* Rutty (1772).

Mus domesticus Rutty, Essay Nat. Hist. County Dublin vol. 1, 1772.

Synonyms.—albus Bechstein (1801), *flavus* Bechstein (1801), *maculatus* Bechstein (1801), *niger* Bechstein (1801), *islandicus* Thienemann (1827), *adelaidensis* Gray (1841), *nudoplicatus* Gaskoin (1856), *varius* Fitzinger (1867), *cinereo-maculatus* Fitzinger (1867), *melanogaster* Minà-Palumbo (1868), *albinus* Minà-Palumbo (1868), *rubicundus* Minà-Palumbo (1868), *poschiavinus* Fatio (1869), *flavescens* Fischer (1872), *simsoni* Higgins and Petterd (1882), *muralis* Barrett-Hamilton (1899), *subterraneus* Montessus (1899), *faroensis* Clarke (1904), *ater* Fraipont (1907), *airolensis* Burg (1921), *jamesonii* Krausse (1921), *subcoeruleus* Fritsche (1928), *formosovi* Heptner (1930), *caudatus* Martino (1934), *mykinessiensis* Degerbøl (1940).

Type locality.—Dublin, Ireland.

Distribution.—Northern Spain, France except the Mediterranean littoral, Channel Islands, British Isles, including the Orkney and Shetland groups, and the north Atlantic islands, *viz.* Hebrides, Faroes, and Iceland. Also the coast of Norway, Germany as far east as the river Elbe (its range slightly east of this river overlapping with that of *M. m. musculus*), Switzerland, probably part of northern Italy, the western and southern parts of the Balkans peninsula, the Ionian islands, and the islands of the Egean archipelago, as far east as Tenedos. An introduced population along the oil-pipe line between Batoum and Baku in Transcaucasia (*"formosovi"*).

Introduced into North America, from Alaska to the northern part of the central states of the United States, also into Hawaii, the Australian mainland, and Tasmania.

Color.—Typical form: back ochraceous, overlaid with black; belly buffy, suffused with black, the individual hairs distinctly banded; no line of demarcation, the color of the back imperceptibly passing into that of the belly; tail not bicolored, brownish black, slightly paler below near the root; feet sepia, with the terminal phalanges white; ears dark brown.

Major variations are found in the pattern, with individuals and local populations (O'Mahony, 1935, 1937) segregated, which approach the *brevirostris* style. Increased black is found individually, or in groups (*"poschiavinus"*), corresponding to a homologous type developed individually, or locally (*"jalapae"*), from *M. m. brevirostris*. A highly specialized

type with the back bluish grey, the belly buffy, with a sharp line of demarcation, and pale feet is found in certain areas of western France (Poitou) and on several islands in the Outer Hebrides, such as Hirta in the St. Kilda group (*muralis*), but apparently nowhere as a homogeneous population. A corresponding type occurs in the Nilgiri mountains of southern India, within a population of *M. m. castaneus*.

Dimensions.—No adequate series from Europe of this, the commonest form, have been available. From the material at hand, it appears that it averages larger than *M. m. brevirostris*, particularly with increasing northern latitude, the largest specimen examined being a female from Hirta island, St. Kilda group, with a head and body length of 103.5 mm., which, however, is approached by one from Dunkerron, Ireland, (102), and one from Salamanca, Spain (100). This is about the size of the largest specimens of *homourus* from the Himalayan mountains in Ladak.

It is maintained as a rule that *M. m. domesticus* (and *brevirostris*) are characterized by the tail length being greater than that of the head and body. This may hold good as an average for parts of Germany and France. It cannot be taken as a constant subspecific character. We have before us specimens from Switzerland with a tail-ratio of 115, from southwestern France with 110, from Ireland with 123, from the Shetland Islands with 117, and from St. Kilda with 136 (another specimen from St. Kilda has 82). The average tail length for populations not too far to the north appears to be indicated by a tail-ratio of somewhere between 90–100.

Differential diagnosis.—The typical form is distinguished from *brevirostris* by the back being overlaid, instead of suffused, with black, by the flank line being absent, by the tail being dark brown, the underside distinctly speckled, and the feet having only the end phalanges white, instead of the whole of the fingers and toes.

Distinguished from *M. m. castaneus* by the ground color being ochraceous, instead of tawny or cinnamon. Compared with Indian specimens, it also differs by larger size, shorter tail, and phenotypically at least, by longer fur.

Nomenclature.—This form has been designated as *Mus musculus musculus* by most modern authors, since Miller (1912) applied this name to it. It has been pointed out by Zimmermann (1935), and by Degerøl (1940), however, that the house-mouse found at Upsala, Sweden, the type locality of *Mus musculus* Linnaeus, is the East European mouse. All the material examined by us shows that the Swedish animal is the East European, not the West European commensal. Therefore, *Mus musculus domesticus* Rutty is the correct name for the common Northwest European house-mouse.

Group of Mus musculus spicilegus Petenyi

WILD FORM

11. *Mus musculus spicilegus* Petényi (1882).

Mus spicilegus Petényi, Természtrajzi Füzetek, vol. 5, p. 114, 1882.

Synonyms.—*acervator* Petényi (1882), *acervifex* Petényi (1882), *canicularius* Petényi (1882), *caniculator* Petényi (1882), *sergii* Valch (1927).

Type locality.—Rakos Plains, Budapest, Hungary.

Distribution.—Southern and south central Russia west of the Volga river, Bulgaria, Roumania, Hungary, and possibly Austria. Western and northern limit of wild type not determined. Only commensal types (*musculus*) occur in northern Russia, Scandinavia, and Germany. Not found south of the Caucasus mountains.

Color.—Back ochraceous, grizzled with black; belly white with ("white") or without ("snowy"), dark underfur; line of demarcation distinct; tail distinctly bicolored; feet completely white; ears pale.

Dimensions.—33 males, 15 females, and one unsexed specimen of really wild *spicilegus* have been examined, including paratypes received from Penténi and other topotypes. A number of these specimens, however, are without measurements or they are unreliable. The best measurements available appear to be those published by Heinrich (1936) for mate-

rial from Bulgaria. These show the following dimensions, which essentially agree with those characteristic of *M. m. wagneri* and are given here for comparison. Head and body: maximum: males, 82; females, 91; optimum: males, 75–80; females, 85–90. Tail-ratio: variation: males, 150–122; females, 120 (1 specimen); optimum not clear, but above 120 for males.

Differential diagnosis.—Distinguished from *M. m. wagneri* as a population, but not in every case individually, by the ground color being always ochraceous, never buffy (as found in *wagneri*).

COMMENSAL

12. *Mus musculus musculus* Linnaeus (1758).

Mus musculus Linnaeus, Syst. Nat. ed. 10, vol. 1, p. 62, 1758.

Synonyms.—striatus Billberg (1827), *albicans* Billberg (1827), *niveus* Billberg (1827), *hortulanus* Nordmann (1840), *nordmanni* Keyserling and Blasius (1840), *helvolus* Fitzinger (1867), *tomensis* Kastchenko (1899), *raddei* Kastchenko (1905), *tataricus* Satunin (1907), *sareptanicus* Hilzheimer (1912), *germanicus* Noack (1918), *heroldi* Krausse (1922), *funereus* Ognev (1924), *borealis* Ognev (1924), *hapsaliensis* Reinwald (1927), *vinogradovi* Argyropulo (1933), *nogaiorum* Heptner (1934), *polonicus* Niezabitowsky (1934), *kaleh-peninsularis* Goodwin (1940).

Type locality.—Upsala, Sweden.

Distribution.—Coextensive with that of the wild type (*spicilegus*), which is replaced by it in and around human habitations. Extending farther west into Central Europe, as far as the river Elbe in central Germany, into Czechoslovakia, Austria, and possibly southern Bavaria. Found in Denmark and the Scandinavian peninsula, its range in the extreme western area locally overlapping with that of *M. m. domesticus*. Extending to the White Sea in northern Russia. Introduced into Siberia along the track of the Siberian railroad, and spreading from it. Now found as far east as Lake Baikal and as far north as Yakutsk. Range extending beyond that of *spicilegus* into Transcaucasia and along the south shore of the Caspian, and Black seas, where it is found in commensal and feral populations.

Color.—Back ochraceous, suffused with black; belly buffy white to ochraceous buffy, with the grey underfur distinct; line of demarcation indistinct, with a yellow flank zone discernible, but the color of the belly definitely lighter than that of the back and without speckling; tail indistinctly bicolored, with the tip black above and below; feet, as far as the metacarpals and metatarsals, drab or sepia, with the toes white; ears pale brown.

Dimensions.—Head and body: maximum: males, 100; females, 114; optimum: males, 85–90; females, 85–90. Tail-ratio: variation: males, 143–92; females, 155–97; optimum for both sexes: northern population (Sweden, Esthonia), 115–120 and 135–140; southern population (East Prussia, Hungary), 105–110, and 125–130. This shows that, although a tail length considerably shorter than that of head and body is the rule, there are individuals where the tail length is hardly less, and sometimes more, than that of the head and body.

Differential diagnosis.—Typical commensal *musculus* differs from typical wild *spicilegus* in having the back suffused, instead of grizzled, with black, in the line of demarcation being indistinct, and the belly buffy, instead of white. Also in having only the toes white, instead of the whole of the foot. If wild and commensal populations from the same general area are compared, it is found that the tail-length in the wild population averages shorter. This is true for populations only, not for individuals. In general it can also be said that sexual differentiation in body proportions is less pronounced in commensals than it is in wild populations.

Compared with the commensals derived from *M. m. wagneri*, it appears that these have longer legs and longer ears (Zimmermann, 1935) and, as a rule, longer tails, which average longer than the length of the head and body. That *Mus musculus domesticus*, and the southern *M. m. brevirostris*, must not necessarily have the long tail they are usually supposed to have is evident from the measurements and ratios given above; also, that tails longer than head and body occur in the commensals of the *spicilegus* group. The mice from Ireland, described as *spicilegus* and *orientalis* by O'Mahony (1935, 1937), and material from the Nor-

wegian coast, both of which we have examined are unquestionably extremes in a varying population of *M. m. domesticus*. The same is true of the so called *muralis* type from St. Kilda, which is only an extreme of a variable local population.

M. m. musculus differs from *M. m. domesticus* in its typical form, particularly as a population, in having the belly buffy and unspeckled, instead of having it speckled, and in having a line of demarcation. In areas where the two overlap, the population of *domesticus* always has the longer tail.

Group of Mus musculus manchu Thomas

WILD FORM

13. *Mus musculus manchu* Thomas (1909).

Mus wagneri manchu Thomas, Ann. Mag. Nat. Hist. ser. 8, vol. 4, p. 422, 1909.

Synonyms.—*yesonis* Thomas (1928), *takayamai* Kuroda (1938).

Type locality.—Chee-Chia Tai, province Kirin, Manchuria.

Distribution.—So far known from the area of the Yalu, and upper Sungari rivers in southeastern Manchuria; also, from the islands of Kyushu, Honshu, and Hokkaido, Japan. Limits of range not known.

Color.—Back buff, grizzled with black, or with increased black superposed; belly white, with ("white"), or without ("snowy"), dark underfur; line of demarcation distinct, no yellow flank line; tail bicolored; feet perfectly white; ears pale, or dark brown.

Dimensions.—Head and body: maximum: males, 87; females, 91 (Manchuria); males, 87; females, 92 (Japan). Optimum: males, 75–80; females, 85–90 (in Manchuria and in Japan). Tail-ratio: variation: males, 159–118 (Manchuria), 130 (Japan, 1 specimen); females, 185–138 (Manchuria), 167 (Japan, 1 specimen). Optimum: males, 155–160; females, 165–170 (Manchuria). The Japanese material at hand is not sufficient to show the range of variation. The specimens at hand fit perfectly into that of the continental population.

Differential diagnosis.—In proportion, this race agrees with *M. m. wagneri*, except that in a population the percentage of very short-tailed individuals is greater, even if compared with East Asiatic *wagneri*. As a population, not always individually, *manchu* also differs from *wagneri* by the presence (and prevalence) of the blackened mutation, which does not occur in *wagneri*, and by the complete absence of the mutation with ochraceous ground color found in populations of *wagneri*.

COMMENSAL

14. *Mus musculus molossinus* Temminck (1845).

Mus molossinus Temminck, Fauna Japan, p. 51, 1845.

Synonyms.—*rotans* Fortuyn (1911), *kurilensis* Kuroda (1924), *orii* Kuroda (1924), *yonakuni* Kuroda (1924), *albula* Minouchi (1928), *kambei* Kishida and Mori (1931), *tokagii* Kishida and Mori (1931), *yamashinai* Kuroda (1934), ? *longicauda* Mori (1939), *kuro* Kuroda (1940).

Type locality.—Nagasaki, Kyushu, Japan.

Distribution.—Japanese, Kuril, and Iki islands; also, recorded from Tanegashima, Yakushima, and Yonakuni; southern limit of range not ascertained. Not occurring in the Riu-Kiu group where *M. m. homourus* ("*caroli*") is found. Probably found in Manchuria, but only one doubtful record is available. Recorded from Korea. The Japanese waltzing mouse is a domesticated form of *molossinus* (Schwarz, 1942).

Color.—Back ochraceous, suffused with black, or with increased black superposed; belly whitish, or buffy, with dark underfur, or slaty; the individual hairs never banded; line of demarcation indistinct, with a yellow flank line present; tail indistinctly bicolored, with the tip black; ears brown or blackish; feet drab, with the toes white.

Dimensions.—Head and body: maximum: males, 72; females, 81; optimum 65–70 for both sexes. A larger type, possibly due to interbreeding with the wild *manchu*, has an optimum of 75–80 for the female. This larger type is not found in the southern islands, and the Iki

group. Kuril specimens average larger, with an optimum of 80–85 for the males, and 75–80 for the females. Tail-ratio: variation: males, 138–119; females, 162–120; optimum variable locally; in Honshu there appears to be an optimum for males and females somewhere between 115–125, and another somewhere between 130–140, apparently with a slightly shorter average for the males. In the Iki islands, and Kyushu, the tails are longer, the average being apparently between 105–110. On the other hand, in the Kuril islands, (where the animals have white belly and feet), the average more nearly approaches the Honshu average. From the measurements given by Kuroda (1928) the same appears to be true for Hokkaido.

Differential diagnosis.—Distinguished from the wild *manchu* by smaller size, the optimum for males and females being about 10 mm less in each case, and by longer tail. In color it differs in having the ground color ochraceous, instead of buffy, the belly buffy (except in the Kuril islands), instead of white, and the line of demarcation indistinct. In the blackened mutation the belly is white in *manchu*, slaty in *molossinus*; *manchu* has the feet completely white, *molossinus* only the toes white, and the metacarpals and metatarsals drab.

In color, the normal (non-blackened) type cannot be distinguished from *musculus*. In *musculus* the blackened type is found only occasionally, however, whereas in *molossinus* it forms an essential part of the population. Moreover, *musculus* is a larger animal, with longer and coarser hair and, as an average, a longer tail. Under parallel conditions, in particular equal latitude, *molossinus* is the smaller, shorter-tailed animal. Moreover, *musculus*, as a rule, has wider posterior nares, usually parallel-sided, with the width of the opening at the anterior third less than three times the length, whereas in mice of the *wagneri* and *manchu* type, including *molossinus*, this width is decidedly more than three times its length and the usual outline of the opening is more or less V-shaped.

Compared to its southern neighbor, *M. m. homourus*, which belongs to the Indian group, *M. m. molossinus* differs by its tail being shorter than the head and body, whereas in *homourus* from the Riu Kiu islands (*"caroli"*), Formosa (*"formosanus"*), and Indochina (*"kakhyenensis"*) the tail is much longer than the length of the head and body. The ground color in *homourus* is tawny or cinnamon, instead of ochraceous; the belly is usually white, instead of buffy; and the blackened mutation is practically absent.

Group of Mus musculus spretus Lataste

WILD FORM

15. *Mus musculus spretus* Lataste (1883).

Mus spretus Lataste, Act. Soc. Linn. Bordeaux vol. 37, p. 27, 1883.

Synonyms.—*hispanicus* Miller (1909), *lusitanicus* Miller (1909), *mogrebinus* Cabrera (1911), *lynesi* Cabrera (1923), *rifensis* Cabrera (1923).

Type locality.—Oued Magra, between M'sila, and Barika, north of the Chott du Hodna, Algerian plateau.

Distribution.—Iberian peninsula, France immediately north of the Pyrenees, Northwest Africa, north of the Atlas mountains; recorded as far east as northeastern Algeria; Balearic islands.

Color.—Back buffy or ochraceous, evenly grizzled with black; belly white with, rarely without, dark underfur; line of demarcation distinct, a yellow flank line may be indicated; tail bicolored, with the tip darker, not black; feet perfectly white; ears pale. Portuguese and Balearic specimens are redder, but not tawny. This may be environmental.

Dimensions.—Head and body: maximum: males, 91; females, 87. Optimum for females from all localities, 75–80; males from the Balearic islands, and from the Portuguese coast have the same optimum as the females. But in the population from Spain and North Africa, an optimum indicating a smaller (70–75) and a larger type of males can be distinguished. Tail-ratio: variation: males, 147–114; females, 165–103. In the populations from Spain, Portugal, and North Africa, where the variation of tail length is considerable, it appears that three types can be distinguished: one with an optimum near 110, a second near 120, and a third near 135. In the Balearic islands the tail-length is less variable, of medium type, and there is not much difference between the sexes (males, 120–125; females, 125–130).

Differential diagnosis.—*M. m. spretus* differs from all the other wild types by its smaller size. In color it cannot be distinguished from true wild *spicilegus* nor from the ochraceous type of *wagneri*. The color differences from *spicilegus* given by Miller (1912) are not correct, as his comparisons were made with the greyer commensal *musculus*, not with the wild *spicilegus*.

ORIGIN AND DISPERSAL OF THE COMMENSALS

Three major centers can be traced where commensal mice have been developed from the wild stock. They are all connected with permanent settlements of an agricultural type. The most important one of these centers is the borderland of Russian Turkestan and the Iranian plateau, where, at an early period (Pumpelly, 1908), wheat and barley were cultivated. The second center is the wheat growing black earth country in southern Russia, north of the Black Sea. The third center is in Japan, thickly settled with a primarily agricultural population.

1. From *M. m. wagneri*, which is the wild mouse of Russian Turkestan, two groups of commensals are derived. Along the ancient roads that connect the oases of eastern Persia, a route can be traced where these early commensals have followed the migrations of Man into areas where the wild stock did not exist, as is suggested by the absence of fossil records.

From Persia (*bactrianus*), a line of invasion goes into northwest India (*bactrianus*) and along the Himalayan chain into Indochina, southern China, and as far north as the Riu-Kiu islands (*homourus*). All these mice are of the white-bellied type and only loosely associated with Man. In the more thickly settled areas of northeastern (*urbanus*) and peninsular India (*castaneus*), dark-bellied commensals have been developed from *homourus*. These are not, as a rule, found away from human habitations and are the ones that have been carried into Burma, Siam, the Malay countries, Australia, and far into Polynesia. These Indian mice have reached by land and by sea-transport the coasts of East and South Africa. The white-bellied group (*bactrianus*) has also been carried by human agency from the coast of southern Persia into southern Arabia and from there into the coastal districts of Somaliland and Kenya. In these areas, the ranges of *bactrianus* and *castaneus* overlap and a hybrid population has been developed, with *bactrianus* prevailing in Hadramaut ("*gentilulus*"), and Somaliland, and *castaneus* in Kenya, the latter gradually becoming entirely dominant towards the south.

The western group, emanating from southwestern Persia, goes through Iraq (*praetextus*) into Syria, Palestine, and Asia Minor, into North Africa as far as the Atlantic, south as far as Khartoum in the Nile Valley (*praetextus*). From North Africa it has reached Italy, Spain (*brevirostris*), and from there has spread all over western Europe (*domesticus*). Its range includes France, England, Ireland, and extends as far north as the Outer Hebrides, Faroe Islands, Iceland, and the whole of the Norwegian coast (where it overlaps and interbreeds with *M. m. musculus*). *M. m. domesticus* goes as far east as the Elbe River in central Germany, but further south it extends all through the Alpine region from where it has reached the western and southern part of the Balkans peninsula.

M. m. brevirostris has been carried to the Latin American countries and to the southern part of the United States, formerly under Spanish rule, along the shipping lanes from the Iberian peninsula. The house mice of the northern part of the United States and of Canada, are derived from *M. m. domesticus*, the house-mouse of northern Europe; they have come over primarily from England, France, and Germany. In the central states where the ranges of *domesticus* and *brevirostris* overlap, there is a mixed population, that to a certain extent is biologically segregated. *M. m. domesticus* has also been carried to Australia and Tasmania.

2. The second center of dispersal in southern Russia has produced the commensal *M. m. musculus* from the local wild *spicilegus* stock. It appears that the time when this commensal was developed, is less remote than that when a commensal population was developed from *wagneri*, however. In fact, *musculus* has not gone beyond a primitive stage of commensalism comparable to *praetextus* in shape and to *brevirostris* in color. The long-tailed grey-bellied type represented by *castaneus* and *domesticus* has not been reached in this series. At present the range of the wild *spicilegus* is limited to the dry area of southern Russia and Hungary

and it appears that it has entirely disappeared from Central Europe, if it ever existed there since the Pleistocene. Only commensal and feral populations are found in Germany, Scandinavia, and northern Russia. As a rule, they have been mistaken for *spicilegus*. *M. m. musculus* has a continuous range but is less widely spread than the commensal derived from *wagneri*. It has followed the Russian colonization of Siberia and, in due course no doubt, will become the common house-mouse in the whole area under Russian rule.

3. In the third center of dispersal, a commensal has been developed from *M. m. manchu*. This is the Japanese *M. m. molossinus*. It is known, outside the Japanese islands proper, only from several islands south and west of the Japanese archipelago and from the Kuril islands. No definite record is available of its occurrence on the Manchurian mainland, although it occurs in Korea. The Japanese commensal is even less removed from *manchu* than *musculus* is from *spicilegus* and not always completely segregated from it.

BIOLOGICAL SEGREGATION

All the wild forms are typical dry area animals, occurring in savannahs, steppes, and even in desert country. They are primarily grass, seed, and grain feeders. Only in association with Man are they found outside this dry zone. Where conditions are such that these mice are not able to survive far away from human habitations, they are confined to houses and their immediate neighborhood. This is particularly true of moist areas, such as southern India and the Malay countries, and of the cold North. This applies more to the advanced than it does to the less specialized types. Where more than one type exists within an established commensal population, however, and where, at the same time, suitable outdoor conditions are available, segregation is possible. The less specialized types, *i.e.* those with shorter tail, and lighter belly, have a tendency to stay in the open or return to the out-of-doors, and develop completely feral habits. An indoor and an outdoor population can thus be developed in the same area. The case of *M. m. homourus* and *M. m. urbanus* in the Himalayan area of northern India is typical in this respect. The same is true in cases where the commensal population is still in an initial stage of evolution and not completely homogeneous, *i.e.* where the characters found in the wild population have not entirely disappeared in the commensal population. Segregation and the development of two populations more or less separated from one another is the result. One of them may be more or less like the original wild form. Cases like that are common in the whole range of *M. m. musculus*.

A third type of segregation is found in the Iberian peninsula and in Northwest Africa. Here the local wild form (*M. m. spretus*) has never developed a commensal because, at the time when human settlements became established, the immigrants themselves brought with them their own commensals, *viz. M. m. praetextus*, and *M. m. brevirostris*.

As a rule, if a population of house-mice is established somewhere, it remains established. Arrivals of a different type usually are not able to survive; anyway, they are not able to change the character of the established population. Neither do the mice in Europe show an influence of the Indian *castaneus* nor do Indian and South African populations of house-mice show any appreciable influence of European stock. Only where the ranges of two populations meet in a broad front, as do those of *domesticus* and *musculus* in Central Germany, or where importation or immigration from various sides enters a vacuum, as in East Africa, in Asia Minor, or in North America, is there a chance of a development of mixed populations produced by promiscuous interbreeding.

SUMMARY

1. Four subspecies can be distinguished in the wild species *Mus musculus* Linnaeus, *viz. M. m. wagneri* Eversmann, *M. m. manchu* Thomas, *M. m. spicilegus* Petényi, *M. m. spretus* Lataste.

2. Three of these, *i.e.* all except *spretus*, have developed commensals.

3. All commensal mice, except those of eastern Europe, Caucasia, Siberia, and Japan, are derived from *M. m. wagneri*. This itself has developed independently an eastern and a western series of commensals.

4. Specialization in all commensals proceeds along the same lines. The wild forms are

white-bellied and short-tailed, the most specialized commensals grey-bellied and long-tailed. There are intermediate types corresponding to the stage of commensalism.

5. In many areas outdoor and indoor types of house-mice are found. The outdoor types are either wild or commensals less specialized than the indoor types.

ANALYTIC KEY

(For details use descriptions)

I. Color of belly.
- (a) snowy: *wagneri, bactrianus, praetextus, spicilegus, manchu, (molossinus), spretus.*
- (b) white: *wagneri, bactrianus, homourus, praetextus, orientalis, spicilegus, manchu, molossinus, spretus.*
- (c) buffy: *(bactrianus), (homourus), tytleri, urbanus, brevirostris, (domesticus), musculus, molossinus.*
- (d) grey: *castaneus, domesticus.*
- (e) bluish grey: *urbanus, brevirostris, (spicilegus), molossinus.*
- (f) bluish grey (speckled): *castaneus, domesticus.*

II. Ground color of back.
- (a) buff: *wagneri, manchu, (spretus).*
- (b) ochraceous: *wagneri, bactrianus, (homourus), praetextus, orientalis, brevirostris, domesticus, spicilegus, musculus, spretus.*
- (c) tawny: *homourus, tytleri, urbanus, castaneus.*
- (d) cinnamon: *homourus, urbanus, castaneus.*

III. Tail-length:
- (a) Tail shorter than head and body (tail-ratio above 100): *wagneri, (homourus), praetextus, orientalis, (brevirostris), (domesticus), spicilegus, musculus, manchu, molossinus, spretus.*
- (b) Tail longer than head and body (tail-ratio less than 100): *bactrianus, homourus, tytleri, urbanus, castaneus, praetextus, brevirostris, domesticus.*

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ON THE HARES OF NORTHERN MANCHURIA

By Anatole S. Loukashkin

Arthur de C. Sowerby in his "The Naturalist in Manchuria" (1923), writing on the hares of Manchuria, stated that "the hares of the Manchurian Region have not been thoroughly worked out yet, that is to say, it is not definitely known how many species occur there, or what are the ranges of those that have already been identified in the country." Our knowledge of the species of hares and their distribution in Northern Manchuria is now clearer and more definite than it was twenty years ago.

The main sources for the records reported below are field observations and collections accumulated by the present writer mostly during the period 1931–1940, while on service with the Manchuria Research Institute at Harbin, Manchuria. He has conducted a number of the expeditions into the distant unexplored corners of that vast country.

Upon compiling all the records concerning the hares of Northern Manchuria we can say that in a territory (N. Lat. 53° 31′—41° 55′ and E. Long. 115° 38′—134° 47′; Ahnert, 1928) covering an area of 1,008,479 sq. kilometers only three species occur. These are:

(1) The tolai hare, *Lepus* (*Eulagus*) *tolai* Pallas, represented by two subspecies: *Lepus* (*Eulagus*) *tolai tolai* Pallas and *Lepus* (*Eulagus*) *tolai* subsp.

(2) The varying hare, *Lepus timidus* L.

(3) The Manchurian forest hare, *Allolagus mandshuricus* Radde.

THE MONGOLIAN OR TRANSBAIKALIAN TOLAI HARE

Lepus (Eulagus) tolai tolai Pallas (1778)

Terra typica: Selenga River in Transbaikalia, Eastern Siberia.

The typical Mongolian or Transbaikalian tolai hare, inhabiting adjacent parts of the Russian Transbaikalia and North-western Mongolia (see Formozov, 1929), penetrates into Northern Manchuria. It occupies the whole highland of Barga up to the Three Rivers District in the north-east, or 13 percent of the Northern Manchuria area.

The altitude of the Barga highland varies from 600 to 900 m above sea level. It has an average yearly temperature of −2.1 to −3.3C°, with a maximum of 35.4C° and a minimum of −46.3C°. (All the climatological, topographical, and geographical terms and data are extracted from Ahnert's reports of 1928, 1931, and 1932.)

In Barga the tolai hare keeps to the lake basins and river valleys in general, where it finds better shelter among the thickets formed by the tall-growing grasses and dwarfed shrubs. It avoids waterless steppes with their scarcer, low-growing vegetation. It is met with in limited numbers along the shores of the Dalai Nor lake, where I found (see Loukashkin, 1937 a, b) it only in thickets of *Lasiogrostis splendens*, the tallest perenial of Barga and Mongolia. The tolai hare is a permanent inhabitant of this plant association and it never comes out of it. It is known to occur in the same environments along the course of the Urshun river, as well as around the shores of Ulan Nor and Bouir lakes.

The tolai hare also inhabits sand dunes, or "barkhans", covered with the shrubs of the *Salis Ledebouri, Caragana microphylla, Crataegus dahuricus* and dwarfed Siberian wild apple (location between Khorhonte and Hailar Stations on the Chinese Eastern Railway). But it prefers such river valleys as Hailarho and Imengol where the willow thickets along thr banks and hummocks overgrown with several species of *Carex* appear to be the best sheltee and foraging grounds, especially in winter. In such a habitat it is quite abundant.

The course of the Khuegol River with its highest barkhans covered with the Mongolian pines, *Pinus silvestris* var. *mongolica*, should be mentioned as another habitat of the tolai hare, but here it is much scarcer than in the Hailarho and Imengol valleys.

In the severest winters, the tolai hares approach close to human dwellings, where they are more protected from wolves and foxes. In the vicinity of Hailer Station, I often found them

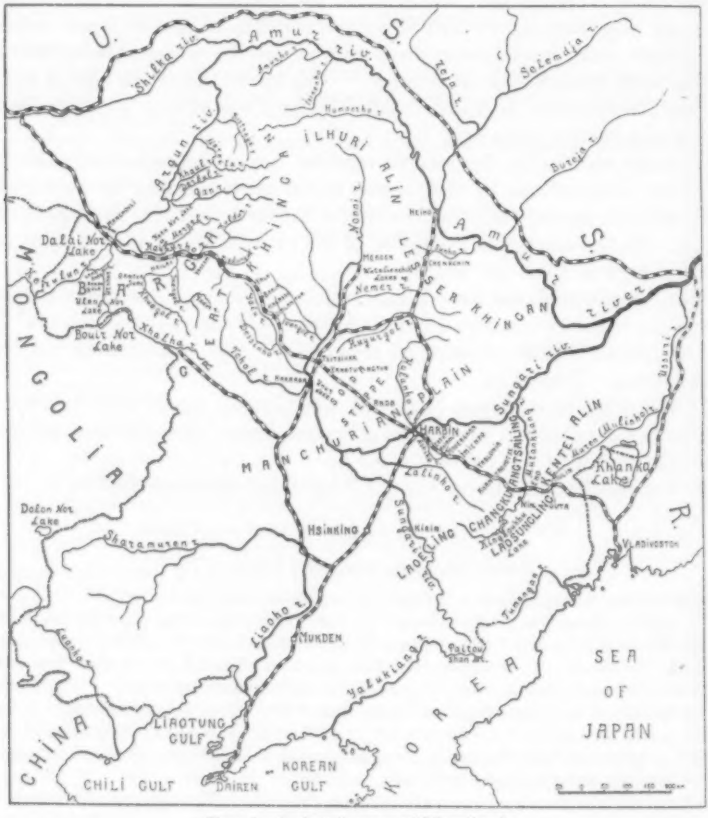

FIG. 1. A sketch map of Manchuria

in forms at a distance of about twenty meters from the houses of the Chinese farmers (Loukashkin, 1929, 1938).

The range of this hare follows up the river courses and gradually ascends the western slopes of the Greater Khingan Mountains, but never penetrates deep into the arboreal zone.

THE MANCHURIAN TOLAI HARE

Lepus (Eulagus) tolai ssp.

Terra typica: Manchurian Plain, Northern Manchuria.

Another region occupied by the tolai hare in Northern Manchuria is almost twice as large

as Barga proper. This is the Manchurian Plain, with Nonni and Sungari the largest rivers of the country, which occupies 24 percent of the Northern Manchuria area.

The altitude varies from 110 to 300 m above sea level. The climate of this region is much warmer than that of Barga. The average yearly temperature varies from 2.4 C° in the north to 4C° in the south, with a maximum of 35.8C° and a minimum of −34.4C°.

The Manchurian Plain is the most intensely cultivated area in Northern Manchuria and onto it extends a continuation of the range of the tolai hare from the adjacent Chahar and Jehol. The eastern slopes of the Greater Khingan Mountains mark the western boundary of the range of this hare on the Manchurian Plain, while the Eastern Manchurian Mountainous Country forms the eastern border. The valley of Nemer River and Mergen, on the Nonni River, are the northernmost points of its range at the present time. The southern boundary lies in South Manchuria, somewhat not far from Mukden. The tolai hare is widely spread throughout the described region and there it is much more abundant than in Barga.

I came across it near Hsinking, in the Lalinho Valley near Tsaichiakou Station on the southern section of the Chinese Eastern Railway, along the Sungari River 100 kilometers down from Harbin, everywhere in the valleys of the Ashiho, Hulanho and Khuyurgol rivers, as well as in the wide valley of the Nonni River with its numerous tributaries (Tor, Tchol,

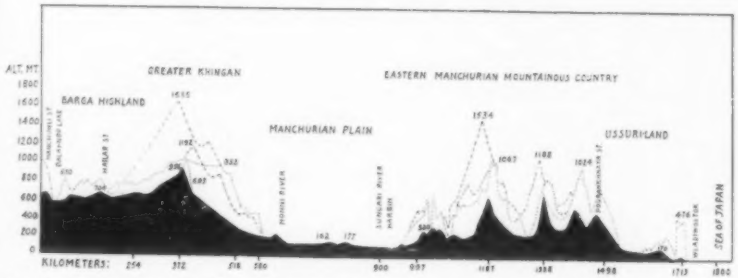

FIG. 2. A profile of the Chinese Eastern Railway across Northern Manchuria and mountains N and S of it (after Edward E. Ahnert).

Legend: Black area: A profile of the Railway line itself. Broken line: Mountains S of the line. Dotted line: Mountains N of the line.

Yaluho and Ivangol) from Mergen to the junction with Sungari. It was recorded in great abundance on the Soda Steppe from Tsitsihar to Harbin (Loukashkin, 1934 a, b, d, 1939a).

The tolai hare reaches the eastern ramifications of the Greater Khingan Mountains following the valleys of the above mentioned right-bank tributaries of the Nonni River. There it inhabits not only the willow thickets in the valleys, but also the woods of dwarfed oak, *Quercus mongolica*, and hazel-nut bushes, *Corulus heterophylla*, growing on the eastern and southern hillsides.

This form of the tolai hare, like a typical one on the western side of the Greater Khingan, avoids the dense forests of the arboreal zone.

The Manchurian tolai hare already occupies the mountain pass near Buhedu, moving up from the Manchurian Plain along the Chinese Eastern Railway line, while the Mongolian tolai hare is moving upland along the same line from Barga. Therefore, in the near future the ranges of the Mongolian and Manchurian hares will practically be linked.

In the mountain pass near Buhedu the Manchurian tolai hare occurs with the varying hare, *Lepus timidus*, hybridizing in this locality.

The tolai hare from the Manchurian Plain is somewhat smaller than the typical form from Barga and Transbaikalia. Its fur tends to be wavy on the rump and back. Moreover, a number of peculiarities in the cranium exist.

Professor S. I. Ognev (1940) of Moskow University, upon receiving my specimens of the

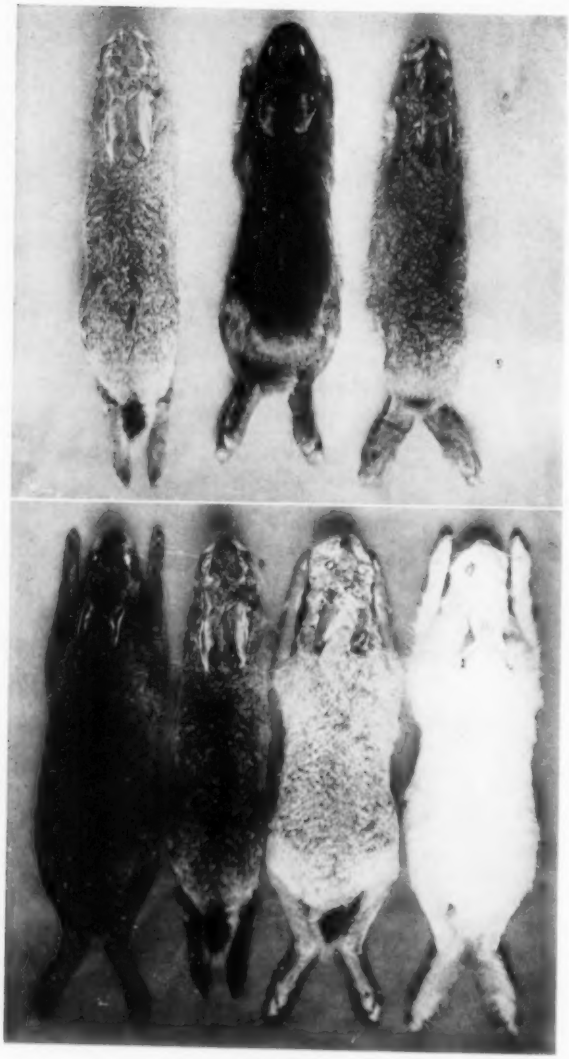

PLATE 1

UPPER: The skins of Manchurian hares (from left to right): *Lepus* (*Eulagus*) *tolai*, melanistic phase of *Allolagus mandshuricus*, and common grey phase of *A. mandshuricus*. All three in winter pelage.

LOWER: The skins of Manchurian hares (from left to right): *Lepus timidus* (summer), *Lepus* (*Eulagus*) *tolai* (winter), hybrid *L. timidus* x *L. tolai* (winter), and *L. timidus* (winter).

tolai hare from the Manchurian Plain, wrote that "On the basis of this data it would be possible to describe the Manchurian hare, as a new subspecies, but I hope to secure more complete materials in order to make this description more correct and concrete. In particular it is necessary to analize the relation between the Manchurian tolai hare, *Lepus (Eulagus) tolai* subsp., and the Gobi sand hare, *Lepus tibetanus gobicus* Satunin."

For this reason I give a separate range to the Manchurian tolai hare and mention it under the name *Lepus (Eulagus) tolai* subsp.

THE TRANSBAIKALIAN VARYING HARE

Lepus timidus transbaikalicus Ognev (1929)

Terra typica—Baikal Lake, Transbaikalia, Eastern Siberia.

The varying hare of Northern Manchuria belongs to the Transbaikalian subspecies. It occupies the main ridge of the Greater Khingan Mountains and its forested branches, or 21 percent of the Northern Manchuria area.

The Greater Khingan attain an altitude as high as 1500–1700 m above sea level, the mountain passes being from 1000 to 1300 m. The average yearly temperature of the region is −2.6C° at lower altitudes and −4C° at higher ones, with a maximum of 32.1C° and a minimum of −46.1C°.

The Argun River from the Three Rivers District to the west, the Amur River to the north, upper course of the Khalha River to the south, and the forestless foothills of the Khingan itself to the east form the boundaries of the range of this hare in Manchuria. Ilhuri Alin Mountains in all probability would be included in the range inasmuch as this mountain system is almost inseparable from the Greater Khingan proper.

The dense forests of the Dahurian type consists of the Dahurian larch, *Larix dahurica*, white birch, *Betula platyphylla*, and Dahurian birch, *Betula dahurica*, with associations of aspen, *Populus Dawidiana*, appear to be the most favourable habitat of the varying hare. The Dahurian rhododendron, *Rhododendron dahuricum*, forms the bushy undergrowth in these forests. Thus, if we look at the map, we can see that the range of the present species divides the ranges of both forms of the tolai hare.

This hare keeps mainly to the upper courses of the rivers, but it tends to descend along the stream where suitable associations are available in the valleys. The groves of poplars and willow thickets along the river banks and on the islets are favored habitats (see Loukashkin, 1934b, c, 1939a). Moving down the river valleys, it reaches the Barga highland, as far as Hailar Station on the Chinese Eastern Railway. In other words, the range of the varying hare extends towards the west by the same routes as does that of the Mongolian tolai hare from Barga to the east.

About twenty years ago the varying hare ceased its movement into Barga because most of the trees and shrubs in the valleys were cut off by the Chinese and Russian settlers. Now its westernmost location on the Barga border is Yakeshi Station on the Chinese Eastern Railway.

As to the eastern slopes of the Greater Khingan, I have no record about the moving of the varying hare towards the Manchurian Plain. These slopes descend abruptly into the Plain, and are at a considerably lower altitude than is necessary for its existence. The varying hare almost entirely disappeared from the regions attached to the line of the Chinese Eastern Railway because of the development of the lumbering industry and intensive trapping.

As it was mentioned above, the Manchurian tolai hares came up from the Manchurian Plain and occupied borders of the range of the varying hare on the eastern slope of the Greater Khingan as far as Buhedu and Yalu Stations on the Railway (alt. 600–750 m). This is the only locality known to produce hare hybrids, *Lepus timidus transbaikalicus* x *Lepus (Eulagus) tolai* subsp.

According to Miss V. F. von-Lude (*in litt.*), who collected mammals and birds in that region from 1933 to 1935, most of the forests disappeared long before her arrival there and

pure varying hares became scarce. The hybrids were met with much oftener than varying hares, while the tolai hares were dominant in the whole hare population of the region. In all probability these hybrids are fertile. Among the winter-taken specimens examined, I found individuals of the first generation with sharply exhibited tolai appearance. In other specimens presence of tolai blood was sometimes marked with a blackish stripe on their tails (the latter being of intermediate length, shorter than in tolai and longer than in varying hare), brownish spot on their ears, muzzles, or backs. Even in some seemingly pure varying hares light-pinkish underfur showed that they had a remnant of tolai blood.

Remark.—The following subspecies of the varying hare are known from Eastern Asia (Ognev, 1940, and Kuroda, 1938):

1. *Lepus timidus gichiganus* J. Allen (1903)—Gichiga, Okhotsk seashore, Anadir r., Kamtchatka peninsula.
2. *Lepus timidus mordenni* Goodwin (1933)—Maritime Province and Ussuriland of the Russian Far East.
3. *Lepus timidus kolymensis* Ognev (1922)—Kolyma river.
4. *Lepus timidus tschukschorum* Nordquist (1883)—N-E periphery of Tchukotka Pen.
5. *Lepus timidus orii* Kuroda (1928)—Saghalien island.
6. *Lepus timidus abei* Kuroda (1938)—Kuriles: Toshimoi in Yetorofu.
7. *Lepus timidus ainu* Barret-Hamilton (1900)—Hokkaido, Japan.

THE MANCHURIAN FOREST HARE

Allolagus mandshuricus Radde (1861)

Terra typica.—Bureja (or Bureya) Mountains, Amur region, Eastern Siberia.

The Eastern Manchurian Mountainous Country (covering 20 percent of Northern Manchuria), bordered by the Sungari, Amur, Ussuri, Tumengan and Yalukiang rivers, is the home range of the *Allolagus mandshuricus*. (The genus *Allolagus* was created by Professor S. I. Ognev in 1929. Its range covers Southern Ussuriland, Manchuria and the Japanese Islands: Hondo and Kiu-Shiu.) (Ognev, 1929.)

The highest ridges of this region are 950–1494 m above sea level. (The highest isolated peak, Paitoushan volcano or the White Head Mountain, has an altitude of 2400 m. It is a dominant mountain over both Manchuria and Korea.) The average yearly temperature is 1.8C° in higher altitudes and 2.8C° in the lowest ones (deep valleys), with a maximum of 32.3C° and a minimum of −33.5C°.

Dense forests of so-called Manchurian flora cover almost all this area. The principal trees growing there are the Korean cedar, *Pinus koraiensis*, Ajan fir, *Picea ajanensis*, two species of *Abies* (*nephrolepis* and *holophylla*), Manchurian ash, *Fraxinus manshurica*, Amur linden, *Tilia amurensis*, Manchurian walnut, *Juglans manshurica*, Amur cork-tree, *Phellodendron amurense*, Manchurian aralia, *Aralia manshurica*, many species of poplar, elm, maple, etc. Exceedingly numerous bushes (*Syringa*, *Kalopanax*, *Ribes*, *Philadelphus*, *Accanthopanax*, *Rosa*, *Corylus* and many others) form dense thickets of undergrowth, while creepers and vines, such as *Actinidia arguta*, *A. kolomikta* and *A. polygama*, *Schizandra chinensis* and *Vitis amurensis* make the forests in many places absolutely impassable.

The Manchurian forest hare is spread throughout the above described area from an altitude of 300 m up to 800–900 m. It is known to keep to the mixed forests, avoiding pure coniferous associations. The broad-leafed woods, where the tall growing Mongolian oak, *Quercus mongolica*, with the Manchurian hazelnut, *Corylus manchurica*, in undergrowth are predominant species, form the most favourable habitat, especially if barren rocks and cliffs are scattered throughout the woods.

The present species is the smallest hare of *Manchuria*, and it has two color phases (1) common dark-grey and (2) the rarer black one. The melanistic phase was first reported from Ussuriland by N. M. Przewalsky in 1870. He called it "black hare". Since then the black phase of the *Allolagus mandshuricus* was twice described as a subspecies and subphase. Noack in 1891 named it as the *Caprolagus brachyurus niger* (from the Lower Amur River), but he did not give a complete description.

Professor Ognev (1922) reported it as the *Lepus mandshuricus melanonotus*. V. K. Arseniev (1921) mentioned the black hare as *Caprolagus sp.*, speaking of it as an undescribed species. For Manchuria proper the black phase was first recorded by Sowerby (1923) under the name of *Lepus mandshuricus*, which is known to occur mainly in rocky places and in the burnt forests.

The Manchurian forest hare does not like open valleys and grassy hillsides and it never approaches human dwellings. The development of the lumber industry rapidly destroyed the forests, reducing the numbers of this hare considerably in the districts where cutting was done.

I have no materials from the Lesser Khingan Mountains, but in all probability the *Allolagus mandshuricus* also inhabits that part of Northern Manchuria, as a great many plant species belonging to the Manchurian flora are recorded for the Lesser Khingan, where the altitudes are almost the same as those of the Eastern Manchurian Mountainous Country. Moreover, this hare is known to occur beyond the Amur River in the Russian part of the Lesser Khingan (Zolotarev, 1936).

Allolagus mandshuricus appears to be an endemic species of the Manchurian Region, in the sense of Sowerby (*op. cit.*), extending from Manchuria proper into the northern part of Korea and the Russian Maritime Province, where the Bureja (or Bureya) Mountains (50°N. Lat.) form the northernmost boundary of its range. There it is known to occur in the mountains of Sikhote Alin up to the Russo-Korean frontier.

Another species, *Allolagus brachyurus* Temminck (1839), is distributed on the Japanese Islands. Speaking of the hares of Northern Manchuria mention should be made of two other species occupying neighboring countries. Their ranges extend or are likely to extend into Southern Manchuria.

First of them is the little known Korean hare, *Lepus coreanus* Thomas, described in 1892 from Seoul and Taiku, Korea. Sowerby (*op. cit.*) suggested that it probably occurs in the Yalukiang valley.

The second species, *Lepus swinhoei* Thomas (terra typica: Peking, China) ranges from Yangtze river northward into the southern parts of Manchuria (along the shores of Liaotung Gulf of the former China province of Mukden) (see Kuroda, 1939).

In recent years the Manchurian tolai hare, *Lepus* (*Eulagus*) *tolai* subsp., has shown a tendency to enter the Eastern Manchurian Mountainous Country. Just after cutting the woods and settling of agriculturists, it came there along the line of the Chinese Eastern Railway. I have records confirming that it is already near Imienpo Station, in the valley of Maiho River.

In the newly occupied region it keeps to the valleys, open hillsides and cultivated fields. Thus it gradually dislodges the *Allolagus mandshuricus* in those places where the woods are exploited by the colonists.

CONCLUSIONS

Summarizing the above information we may state the following:

1. Three species of hares belonging to two genera are proved to inhabit Northern Manchuria: *Lepus* (*Eulagus*) *tolai*, *Lepus timidus* and *Allolagus mandshuricus*.

2. There are two forms of tolai hares, *Lepus* (*Eulagus*) *tolai tolai* Pallas and *Lepus* (*Eulagus*) *tolai* subsp., each of which occupies different regions.

3. The Manchurian tolai, *Lepus* (*Eulagus*) *tolai* subsp., in its easternmost boundary on the Greater Khingan Mountains cross-breeds with the varying hare, *Lepus timidus transbaikalicus*, creating quite a considerable population of hybrids.

4. The Transbaikalian varying hare, *Lepus timidus transbaikalicus*, is distributed in the highest mountains of the country (Greater Khingan). The forests of the Siberia-Dahurian type cover that area.

5. The Manchurian forest hare, *Allolagus mandshuricus*, inhabits the Eastern Manchurian Mountainous Country (and probably the Lesser Khingan Mountains). Dense forests of Manchurian flora cover this region.

6. *Lepus timidus* and *Allolagus mandshuricus* have suffered from human activities (lumber industry, hunting, and agriculture). As a result they move far away from the railway lines and settlements.

7. At the same time the tolai hare has extended its range year by year, finding favorable conditions everywhere. This is true especially of the *Lepus* (*Eulagus*) *tolai* subsp., occupying the Manchurian Plain, which recently appeared in the range of the *Allolagus mandshuricus* in the Eastern Manchurian Mountainous Country. The tolai hare also shows a tendency to appropriate the range of the varying hare on the Greater Khingan, maintaining agression from both directions: eastwardly from Barga and westwardly from the Manchurian Plain.

8. Undoubtedly in the future with cutting the greater parts of the forests and the intensive colonization only the tolai hare will exist successfully. The two other hares will become extinct. The tolai hare is not restricted either to the forests or to the virgin steppes. This is a reason for its successful association with cultivated areas. It can live even in the suburbs of cities and at the edges of villages. Sometimes it appears in the central streets of Harbin (Loukashkin, 1939c). I have several times found its tracks in the fresh snow on the Cathedral Square near the museum of the Manchuria Research Institute, from where I traced them through the city to the suburbs. From the tracks it was evident that the tolai hares travelled quietly in the night along the sidewalks and pavements, which were well lighted with electric street lamps.

9. The construction of the 1500 km line of the Chinese Eastern Railway in 1898 is reflected in the plant and animal life in general, and in the continual changes on the borders of the range of the hares in particular.

10. The Manchurian fauna in itself is characterized by a mixture of northern and southern elements. This may be observed with our three species of hares, of which the *Lepus timidus* appears to be a component of the adjacent boreal faunistic region, while the *Allolagus mandshuricus* belongs to the southern fauna. In *Lepus* (*Eulagus*) *tolai* we have an animal peculiar to the fauna of Central Asia.

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RATIO OF THE CROSS-SECTION OF THE AORTA TO THAT OF ITS BRANCHES IN MAN AND THE SILVER FOX

By Marcus A. Krupp

In studies on the caliber and course of blood vessels, various techniques have been used. Schiefferdecker (1882), Krassuskaja (1903), and Huber (1906–1907) used celloidin and camphor dissolved in acetone, with colored colloidal dyes, without regard to the effect of the liquids upon the musculature of the vessels. Hence their results required revision. Hochstetter (1886) said that he added kaolin to his celloidin solutions to prevent shrinkage of the cast as it solidified, but its presence in the solution could not neutralize the effect of the latter on the vessels. Flint (1901–1902) employed rather concentrated aqueous suspensions of Prussian blue or of Victoria blue which he claimed set without shrinkage. Thomé (1900), who used a mixture composed of 30 grams of plaster of Paris, 1 gram of rye meal, 30 cc of a 1/3 percent starch paste, and a little dye, obtained results which have been regarded as accurate because he injected his preparations under a pressure equal to the mean systolic blood pressure. However, Thoma (1886, 1922), who also made many measurements of blood vessels, injected paraffin (m.p. 52° C.) heated to 65–70° C. and hardened it by pouring ice cold saline over the vessels. Camera lucida tracings were then made of cross sections and the tracings measured. Aside from changes in caliber due to death and differences in temperature, even if not in pressure, contraction of the paraffin upon solidification must have resulted in measurements that were too small. Beneke (1878), on the other hand, cut the vessel longitudinally, spread its wall out on a flat surface and measured the inner circumference. Blum (1919) employed a method devised by Rohner (1919), which was based on the premise that when vessels are subjected to equal blood pressures, the ratio of the cross section area of the stem vessel to the sum of the areas of the cross sections of its branches, will be comparable to the ratio of the weight of a length of the wall of the stem vessel to that of the sum of the weights of equal lengths of each of the branches. Yet the vessels were stripped of "connective tissue", dried, cut into equal lengths, treated with ether, dried again and weighed! Rouslacroix (1925) and Lyon (1930) believed they had obtained accurate measurements of the coronary arteries of various animals from skiagrams of the excised heart and vessels injected with lipiodol during life. Hinman, Morison, and Lee-Brown (1923) used several techniques, including celloidin, barium sulphate or bismuth subnitrate in gelatin, and 2 percent Berlin blue in distilled water.

I used none of the above methods, for I felt they were no more reliable than measurements made directly on the vessels, and reliable methods for measuring the varying caliber of blood vessels in the living animal are unknown.

For part of this study, the aortae from 14 recently killed (within twelve hours) adult silver foxes (*Vulpes fulva*) were removed, washed in warm saline, and the inner caliber measured at once. The measurements were made with duralium cones, calibrated in millimeters from 1 to 35. The pitch of the cones was slight, intervals of about 4 mm separating the successive calibrations in millimeters.

The cones were introduced into the orifices with only enough pressure to make the latter circular, and to bring the walls in contact with the complete circumference of the cones. Fractional lengths of a millimeter were estimated.

The aortae of the foxes were measured: (1) just distal to the aortic sinuses, (2) between the origins of the innominate and left common carotid arteries, (3) between the origins of the coeliac and superior mesenteric arteries, and (4) five millimeters proximal to the division of the aorta into the common iliac arteries.

The accurate measurement of arteries post mortem not only is difficult, but may not be a correct index of their intravitam caliber. Since these aortae were fresh, unfixed, and empty, the actual measurements undoubtedly are smaller than if they had been obtained when the vessels were distended by fluid at a pressure equal to the mean systolic blood pressure of the fox. The data obtained from fox aortae and their branches are given in Table 1. Table 2 gives the ratios, expressed in percentages of the total cross section area of all the branches originating from the aorta, to the cross section area of the latter at the level of the coronary arteries, for man and fox, and the ratio of the total area of the branches to the area of the human aorta in the region between the innominate and left common carotid arteries for man. The increase in the area of the stream bed of branches of the aorta ranges from 72 to 148 percent. Averages of all the data gathered on man are contained in Table 3, which also includes measurements by Krause (1879) and Thoma (1922). Maximum and minimum diameters of human arteries are listed in Table 4.

The human aortae were removed from embalmed cadavers without gross evidences of disease in the vessels concerned. They included ten white males 27, 43, 49, 50, 53, 55, 57, 59, 65, and 71 years old, one white female 49 years of age, and one Mongolian male 53 years of age. The calibers of these vessels probably were no smaller than during life, because the vessels had been distended somewhat by the embalming fluid injected under pressures somewhat higher than normal blood pressure, within two days and often within less than one day after death. There probably was some distension and there may have been slight contraction of the branches of the aorta, but probably not of the latter. Since the walls of the vessels were soft and pliable because of the large proportion of glycerine in the embalming fluid, only slight force was required to introduce the cones as described above. The measurements made on man were the same as those made on foxes, except that the length of each human aorta was also measured on its ventral surface as nearly as possible in a line parallel to the axis of the vessel, between the origins of the coronary and common iliac arteries.

The data on man in Table 2 reveal a range in the ratios of the areas of the branches to that of the aorta at the level of the coronary arteries, from −26.4 to +23.0 percent. There was a decrease in 8 of the 12 cases. The ratios of the area of the stream bed of the branches to that of the aortae, as determined between the innominate and left common carotid arteries, on the other hand, ranged only from a decrease of 12.5 in only one instance to an increase of 13.5 percent. This surprising difference between the extremes in the two cases may be due to varying effects of the embalming fluid upon the different portions of the aorta, or to differences in effect of the pressure used in embalming, upon

different portions of this vessel, for the ratios obtained upon the fox killed by gas revealed no such fluctuations.

Since the ratios obtained from Krause's and Thoma's data compare favorably with my own, and since the maximum and minimum measurements recorded in Table 4, compare favorably with those reported by Krause (1879) and Vierordt (1893), my findings probably are not exceptional. Calculations made by Thoma (1893) with Beneke's (1878) measurements, as recorded in Table 5, compare favorably with my ratios of the areas of the abdominal aortae to the areas of all branches, but my ratios of the areas of the ascending aortae to those of their branches are smaller than those computed by Thoma from Beneke's data. This discrepancy is due, in part, to the fact that Beneke measured the ascending aorta a centimeter or two above the aortic valves, while I measured it nearer the arch, at the level of the origin of the innominate artery. When the area of the aorta at the coronaries is used in the calculations, my values, given in the extreme right column of Table 5, exceed those of Thoma and Beneke. If the Vierordt-Krause results are placed in the decade from 50 to 60 years, in which most of my cases fall, they show the same variation from Thoma's results as mine do. Since the aorta is considerably smaller just distal to the aortic sinuses, my ratios probably would have agreed more closely with Thoma's had I taken my measurements there.

MacWilliam (1902) studied the changes in the arterial walls in oxen and sheep at various periods after death, under varied conditions of temperature and pressure, and Fuchs (1900) and Lyon (1930) confirmed MacWilliam's work on dogs and cats respectively. These investigators found that temperature and pressure alone may cause variations in caliber of 75 to 100 percent. Lyon (1930) claimed that the empty aortae of smaller mammals measured at 37°C. within 24 hours after death have cross section areas only about 25 percent of those of the same vessels distended with fluid under a pressure equal to that of the mean systolic blood pressure. Because the vessels of larger animals are less elastic, he found this reduction in area only about 50 percent in them.

My results in man confirm Thoma's (1893) generalization that after the fortieth year the cross section area of the ascending aorta is slightly greater than the sum of the cross section areas of its branches, a generalization which, according to my data, holds also for the abdominal aorta near its bifurcation into the common iliac arteries. From Table 2 it is evident that the sum of the cross section areas of the branches of the aorta is smaller than the cross section area of the aorta at the level of the innominate artery. Thomé (1900) showed that in the dog the sum of the cross section areas of the branches of the aorta is only 97 percent that of the latter just superior to the semilunar valves. So it seems that in adult man and in the dog there is no significant change in area of the stream bed of the branches of the aorta when compared with that of the aorta itself; in the adult fox, on the other hand, there appears to be a great increase in stream bed of the branches.

I wish to express my appreciation to Dr. A. W. Meyer, Department of Anatomy, Stanford University, for suggesting this problem and for his interest and criticisms.

TABLE 1.—*Average measurements of the fox aorta and its branches*[1]

ARTERY	AORTA AT LEVEL INDICATED		RIGHT		LEFT		TOTAL AREA	RATIO[2]
	Diam.	Area	Diam.	Area	Diam.	Area		
Coronary	9.4	69.63	2.2 (13)	4.05 (13)	2.8 (15)	6.71 (15)	10.76	1.88
Innominate			4.5	16.26			16.26	
Subclavian	7.4	43.06			3.7	10.94	10.94	
Intercostal (avg.)			1.3 (Av.)	1.38 (Av.)	(x 9 x 2)		25.04	
Coeliac			2.7	5.86			5.86	
Superior mesenteric	5.4	23.28	3.5	9.47			9.47	
Inferior mesenteric			1.9	2.88			2.88	
Renals			2.5	4.96	2.4	5.21	10.17	
Lumbar			2.4 (Av.)	1.48 (Av.)	(x 6 x 2)		16.76	
Common iliac			2.9	6.45	2.9	6.65	13.10	
Middle sacral			2.4	4.66			4.66	
Caudal			1.9 (7)	2.82 (7)	1.8 (6)	2.54 (6)	5.36	
Total							131.26	

[1] In cases in which measurements are based on fewer than 14 foxes, the number taken is given in parentheses following the measurement. Diameters in all tables are given in millimeters, areas in square millimeters.

[2] Ratio of the total area of the branches to that of the aorta, at the level indicated, expressed in per cent.

TABLE 2.—*Comparison of total cross section area of branches to that of aorta in man and fox*

HUMAN BODY NO.	A	B	FOX NO.	C
750	73.6	87.5	1	201.1
757	121.9	178.2	2	172.5
759	120.5	151.5	3	174.8
763	123.0	199.8	4	180.8
766	85.5	118.5	5	181.0
767	80.4	146.7	6	171.3
771	80.4	148.0	7	196.8
772	97.1	184.2	8	207.0
773	120.0	235.0	9	248.0
775	92.7	142.5	10	182.8
776	74.5	138.0	11	179.9
785	95.9	170.6	12	176.3
			13	191.0
Average	97.4	158.7	14	172.0
Vierordt-Krause	107.5–126.5	191.0–224.1	Average	190.0
Thoma	—	140		

A. and C. Ratio of the total area of the branches to the area of the aorta at the coronaries. B. Ratio of the total area of the branches to the area of the aorta between the innominate and left common carotid. All ratios are expressed in per cent.

TABLE 3a.—*Average diameter and area of the human aorta and its branches*[1]

ARTERY	AORTA AT LEVEL INDICATED		RIGHT		LEFT		TOTAL AREA	RATIO[2]
	Diam.	Area	Diam.	Area	Diam.	Area		
Coronary	29.9	707.94	4.1	13.99	4.3	14.98	28.97	100.0
Innominate			11.8	111.65			111.65	
Subclavian	23.6	447.20			9.9	77.86	77.86	158.4
Common carotid					8.5	57.19	57.19	
Intercostal (avg.)			1.9	2.80	(x 10 x 2)		56.00	
Coeliac			5.9	29.14			29.14	
Superior mesenteric	17.6	247.24	8.1	52.68			52.68	
Inferior mesenteric			3.5	9.89			9.89	
Inferior phrenics			1.6 (5)	2.02 (5)	1.6 (5)	2.28 (5)	4.30	
Esophageals			1.4 (11)	1.66 (11)	1.5 (9)	1.83 (9)	3.47	
Renals			6.38	32.64	6.0	30.39	63.03	
Common iliac	14.88	175.64	9.7	74.15	9.67	74.74	148.89	
Lumbar (avg.)			2.06	3.4	(x 4 x 2)		27.20	
Middle sacral			2.1 (6)	4.17 (6)			4.17	
Internal spermatic			1.0 (2)	0.79 (2)	1.0 (2)	0.79 (2)	1.58	
Anomalous left vertebral					4.0 (1)	12.57 (1)	12.57	
Anomalous left colic					5.0 (1)	19.64 (1)	19.64	
Total							708.23	

[1] In cases in which measurements in this and table 4 are based on fewer than 12 bodies, the number taken is given in parentheses following the measurement. Average age of the 12 bodies was 53½ years and the average length of the aorta (10 bodies), 48.3 cm.

[2] Ratio of the total area of the branches to that of the aorta, at the level indicated, expressed in per cent.

TABLE 3b.—*Calculated from data recorded by Thoma* (22)

ARTERY	RIGHT		LEFT		TOTAL	RATIO[1]
	Diam.	Area	Diam.	Area		
Aorta ascendens	22.4	394.08				140.0
Coronaries	4.0	12.57	4.4	15.20	27.77	
Subclavian	6.93	37.72	6.18	29.99	67.71	
Common carotid	6.51	33.28	6.19	30.09	63.37	
Bronchials (average)	1.4	1.54	(x 3)		4.62	
Intercostals (average)	2.6	5.3	(x 9 x 2) (sic)		95.6	
Coeliac	7.0	38.49			38.49	
Superior mesenteric	6.0	28.27			28.27	
Inferior mesenteric	5.4	22.9			22.9	
Internal spermatic	2.0	3.14	(x 2)		6.28	
Renals	6.18	29.99	(x 2)		59.98	
Common iliacs	7.60	45.36	7.59	45.24	90.60	
Lumbar	2.0	3.14	(x 2 x 5) (sic)		31.4	
Middle sacral	3.0	7.07			7.07	
Miscellaneous	1.0	0.79	(x 10)		7.9	
Total					551.96	

[1] Ratio of the area of the branches to that of the ascending aorta expressed in per cent.

TABLE 3c.—*Compiled from data as given by Vierordt (1893) from Krause (1879)*

VESSEL	AORTA		RIGHT		LEFT		TOTAL AREA	RATIO[1]
	Diam.	Area	Diam.	Area	Diam.	Area		
Coronary	32.0	804.3	3.6	10.17	2.8	6.15	16.32	107.7–126.2
Innominate			14.0	153.9			153.9	
Subclavian	24.0	452.4			10.0	78.5	78.5	191.6–224.1
Common carotid					8.6	58.08	58.08	
Bronchials			1–2.3	0.79–4.13	(x 2)		1.58–8.26	
Intercostal			2.8–3.4	6.15–9.07	(x 10 x 2)		123.0–181.4	
Esophageal			0.6–1.0	0.28–0.79	(x 2)		0.56–1.58	
Inferior phrenic			2.3	4.15	(x 2)		8.3	
Coeliac			9.0	63.62			63.62	
Superior mesenteric	20.0	314.2	9.6–10.1	72.38–80.12			72.38–80.12	
Inferior mesenteric			3.8	11.34			11.34	
Renals			5.6–6.8	24.63–36.31	(x 2)		49.26–72.62	
Common iliac	17.0	227.0	11–12	95–113.1	(x 2)		190–226.2	
Lumbar			2.3–2.8	4.15–6.15	(x 4 x 2)		33.2–49.2	
Middle sacral			2.8	6.15			6.15	
Total							866.19–1015.59	

[1] Ratio of the area of the branches to that of the aorta, where indicated, expressed in per cent.

TABLE 4.—*Maximum and minimum diameters of adult human arteries*

ARTERY	DIAMETER	
	Maximum	Minimum
Aorta: at coronaries	34.0	24.0
left common carotid	29.0	17.0
superior mesenteric	21.0	14.0
common iliacs	17.0	12.5
Coronaries: right	5.5	2.0
left	5.5	3.5
Innominate	15.5	9.0
Left subclavian	11.0	8.0
Left common carotid	9.5	7.0
Intercostals (average)	2.3	1.6
Esophageals: right (11)	2.0	1.0
left (9)	2.0	1.0
Inferior phrenics: right (5)	2.0	1.0
left (5)	2.5	1.0
Coeliac	9.5	3.7
Superior mesenteric	10.0	6.5
Inferior mesenteric	4.5	2.5
Renals: right	8.0	5.0
left	8.5	5.0
Common iliacs: right	11.0	7.5
left	11.5	7.5
Lumbar (average)	2.6	1.8
Internal spermatic: right (2)	1.0	1.0
left (2)	1.0	1.0
Middle sacral (6)	3.5	1.0

TABLE 5a.—*Comparison of the Thoma calculations based on Beneke's data with my data and calculations (areas in square millimeters)*

AGE	BODY NO.	(a) AORTA ASC.	(b) L SUB-CLAV.	(c) L COM. CAR.	(d) R SUB-CLAV.	(e) R COM. CAR.	(e') INNOM.	(f) AORTA THOR. DESC.	(g) SMALL BRANCHES	(h) SUM OF b TO g	RATIO a TO h	RATIO AORTA AT COR. TO h
26–30	Thoma-Beneke	291.8	35.4	25.5	42.3	26.4		145.7	29.2	304.5	0.96	
27	773	227.0	52.81	38.49			63.62	153.9	36.18	345.0	0.66	1.31
40–50	Thoma-Beneke	378.3	39.6	24.8	45.8	26.4		185.7	37.8	360.1	1.05	
43	776	380.1	78.5	56.74			86.59	201.1	18.9	471.83	0.81	1.50
49	757	363.05	66.47	50.27			113.1	246.05	30.87	506.76	0.72	1.05
49	763	380.1	95.0	63.62			113.1	254.5	31.42	557.64	0.66	1.10
50	771	490.9	95.0	70.88			113.1	283.5	31.68	594.16	0.83	1.53
50–60	Thoma-Beneke	448.7	50.8	27.2	54.4	27.1		220.2	44.9	424.6	1.06	
	Vierordt-Krause	452.4	78.5	58.08			153.9	314.2	70.94	676.62	0.67	1.19
									108.84	713.52	0.64	1.13
53	775	490.9	81.71	70.88			118.82	254.5	30.06	555.97	0.88	1.36
55	766	615.8	86.59	67.93			143.13	346.4	24.28	667.33	0.92	1.28
57	772	452.4	95.0	63.62			113.1	283.5	54.06	609.28	0.74	1.40
59	750	593.9	78.5	44.17			95.0	227.0	26.82	471.49	1.26	1.5
60–70	Thoma-Beneke	486.6	50.1	25.8	56.7	25.6		242.1	48.7	449.0	1.08	
64	785	397.6	67.93	50.27			113.1	201.1	33.73	466.13	0.85	1.52
67	767	314.2	50.27	38.49			78.5	201.1	20.48	401.41	0.78	1.42
70–80	Thoma-Beneke	544.3	65.1	31.5	62.4	29.7		279.9	54.4	523.0	1.04	
71	759	660.5	86.59	70.88			188.69	314.2	62.71	722.99	0.91	1.14

TABLE 5b.—*Comparison of the Thoma calculations based on Beneke's data with my data and calculations (areas in square millimeters)*

AGE	BODY NO.	(i) AORTA ABDOM.	(j) R COM. ILIAC.	(k) L COM. ILIAC	(l) SMALL BRANCHES	(m) SUM j+k+l	RATIO i/m
26–30	Thoma-Beneke	77.9	30.9	30.9	6.0	67.8	1.15
27	773	132.7	70.88	70.88	10.16	151.92	0.87
40–50	Thoma-Beneke	101.7	44.1	42.1	7.8	94.0	1.08
43	776	132.7	63.62	50.27	10.16	123.05	1.07
49	757	183.85	78.5	73.9	13.89	166.29	1.10
49	763	227.0	95.0	103.86	12.56	211.42	1.08
50	771	176.7	78.5	70.88	22.56	172.14	1.03
50–60	Thoma-Beneke	127.0	50.8	48.6	9.8	109.2	1.16
	Vierordt-Krause	227.0	95.0	95.0	22.75	212.75	1.07
			113.1	113.1	31.1	256.95	0.89
53	775	143.14	63.62	67.92	18.74	150.28	0.95
55	766	227.0	73.9	95.0	13.84	182.74	1.23
57	772	213.8	95.0	95.0	22.18	212.18	1.01
59	750	165.1	63.62	44.17	12.56	120.35	1.37
60–70	Thoma-Beneke	132.8	49.3	54.2	10.2	113.7	1.17
64	785	181.45	67.93	70.88	19.63	158.44	1.15
67	767	122.71	44.18	50.27	12.56	107.01	1.14
70–80	Thoma-Beneke	149.9	67.9	70.7	11.5	150.1	1.00
71	759	201.1	95.0	103.86	19.39	218.25	0.92

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THE OESTRUS CYCLE IN TARSIUS: OBSERVATIONS ON A CAPTIVE PAIR

By H. R. Catchpole and J. F. Fulton

The important position of *Tarsius* in the phylogeny of the Primates, and the rarity of living material, may justify publication of some observations made on a pair of animals maintained in captivity over 18 months. These animals were briefly described in a previous note (Catchpole and Fulton, 1939).

History.—The tarsiers were captured at Barrio Bad-As, Surigao, Mindanao Province, Philippine Islands, in May 1938, as an adult female and her small male baby. They were kept as pets for a few months and were then brought to the United States, arriving at the laboratory on November 21, 1938. Following a somewhat anxious initial period of dietary experimentation, they were maintained almost exclusively on mealworms (*Tenebrio*), which they consumed at the rate of 50 to 60 each per day. The tarsiers ignored other foods offered them. Two or three times a week a salt mixture and cod liver oil were added to the dish of larvae, and this supplement was eaten with the larvae. The animals seemed to flourish on this somewhat monotonous diet, as can be seen from their weight records (Table 1). Both animals were apparently unusually fine specimens compared with other tarsiers taken from near this same locality. Among preserved specimens collected by Dr. J. F. Fulton in Mindanao and Bohol there are 11 males ranging from 85 to 183 grams and 13 females weighing from 83 to

162 grams. In the spring of 1940, the female become noticeably fat, and her weight increased.

During eighteen months of captivity both animals remained in excellent physical condition and showed considerable nocturnal activity. In the nineteenth month the female lost weight rapidly over a period of three weeks and was finally found moribund, and killed. Autospy showed ulceration and hemorrhage in the gastric mucosa, a condition which may have resulted from a cumulative dietary deficiency. The animal was found to be suffering also from an extensive subcutaneous infestation of parastitic worms, *Sparganum* sp. We are indebted to Prof. Justus F. Mueller, The New York State College of Forestry, Syracuse University, for positive identification of this parasite. Some two weeks later the male showed similar signs of weakness, loss of weight, and irritation, and was sacrificed. At autopsy the same parasite was found, chiefly as subcutaneous encapsulated knots in the region of the neck, back, abdomen, and groin. Gastric symptoms, however, were absent.

Procedure.—Except for a month in the summer of 1939, the female was observed almost daily for 17 months. Vaginal smears were taken on most of these

TABLE 1.—*Weights of Tarsiers in Grams*

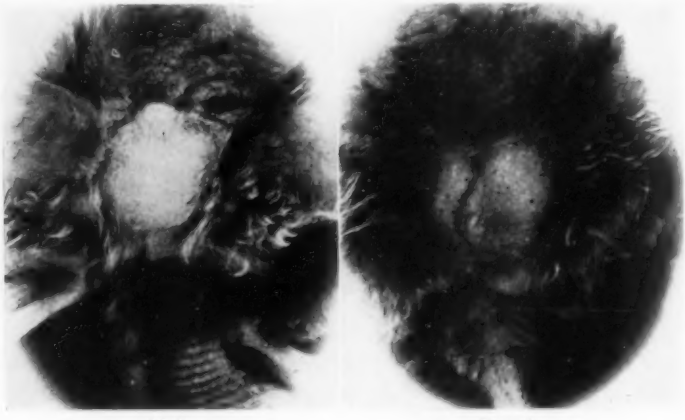
DATE	FEMALE	MALE
November 1938	164	106
May 1939	208	155
November 1939	212	171
May 1940	220	165

days; a few drops of saline were introduced into the vagina and withdrawn by means of a small pipette. This operation was conveniently performed in the late evening when the animal could always be found clinging to the wires of the cage. At the same time, the extended posture allowed the external genitalia to be examined.

External Genitalia of Tarsius.—The genitalia of the female *Tarsius* are illustrated in Plate I, with those of the male added for comparison. The male showed a well defined scrotum with descended testes. At this time he was some 18 months to 2 years old and probably was mature, although overt sexual behavior was never observed. In the female the corresponding labia majora were well marked. The labia minora, which showed cyclical congestion and regression, were, in this picture, taken four days after maximal cornification, in a state of returning quiescence. The pictures of the genitalia of *Tarsius* given by Pocock (1918) are somewhat misleading in the light of our observations on the living animal.

Results.—Observations were started early in January 1939, and a gross vulval swelling was first observed on January 26. A vaginal smear taken on this day showed an abundance of leucocytes with epithelial cells partly nucleated and partly becoming cornified. Cornified cells continued to appear in the smear

in increasing proportion till January 30, when all epithelial cells were cornified, and leucocytes had almost completely disappeared. On the following day a leucocytic reinvasion began and the clumps of cornified cells became heavily infiltrated with masses of these cells. The vulval swelling had by now receded and the previously puffy and separated vulval lips became approximated. Subsequent vaginal smears showed that cornified elements disappeared for the most part in another day or two, leaving a "resting" smear of leucocytes and nucleated epithelial cells indistinguishable from the dioestrus phase of the rodent cycle. On February 20, vulval swelling denoted the initiation of a fresh phase of activity. Using as day of reference the point of maximum cornification, cycles recurred on February 24, March 20, April 12, May 7, June 3–4, June 27–28. The mean length of these cycles was 24.6 ± 0.6 days. No observations were



Male Female

PLATE I

The external genitalia of Tarsius (actual size)

made from July 5 to August 20, a period which might have been expected to cover two additional cycles on July 23 and August 17. Continuous observations from August 20 showed no activity till November 9 when a typical vaginal cell cycle was initiated by the usual signs of vulval swelling. Thus the animal experienced a quiescent period of at least 81 days, with the possibility of a longer quiescence up to a maximum of 144 days from July to October. Following the resumption of activity which reached a maximum on November 12, further phases were observed on December 7, December 27–28, January 21–22, February 13–14, March 4–5 and March 23, giving 6 additional cycles of mean length 22.8 ± 1.0 days. In general the phases of cellular activity in the vagina followed the pattern described. The picture of full epithelial cornification with almost complete disappearance of leucocytes was usually maintained not longer than 24 hours, when rapid leucocytic reinvasion began.

Deviations from this pattern took the form of a less complete disappearance of leucocytes. Such incomplete smears were found on April 12 and December 7, 1939, and on February 13–14, 1940. Even in these cases the point of leucocytic reinvasion was easily recognised. Following the cycle of March 23, the cycles became irregular and cornification failed to appear on or about the expected dates of April 12 and May 1; however, practically complete cornification recurred on the next expected date, May 19. After this date, the animal's health failed rapidly until death on June 16. In view of the findings of Goodman and Wislocki (1935) in *Ateles*, a continual careful search was made for signs of bleeding in this form. Although diligent examination occasionally revealed isolated red blood cells in smears taken at various times, a periodic extravasation of blood was not recognised in this female tarsier.

SUMMARY

1. Twelve vaginal cycles have been followed in a mature female tarsier over a period of 17 months. Their mean length was 23.5 ± 0.7 days.

2. There was no periodic appearance of red blood cells in the vaginal smear.

3. Cyclical activity was absent during a period between August 21 and November 9.

This study was aided by grants from the Fluid Research Funds, Yale University School of Medicine.

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Laboratory of Physiology and the Adolescence Study Unit, Yale University School of Medicine, New Haven, Connecticut.

THE RESPIRATORY EXCHANGE OF *TARSIUS SPECTRUM*

By Robert W. Clarke

The spectral tarsier is the one primate least often found in captivity except close to its natural haunts. The care and habits of such captives have been described previously in this journal (Cook, 1939). Some of the difficulties of transporting them to and maintaining them at laboratories where facilities are available for their observation and study have been described by Fulton (1939), and the successful importation of two specimens into this country from the Philippines by Mr. J. S. Eckman has been briefly noted by Catchpole and Fulton (1939). It is these two animals on which the experiments recorded below were carried out.

The respiratory metabolism of *Tarsius* has apparently never been measured. The recent bibliography of the primates by T. C. Ruch (1941) lists no studies of respiration, basal metabolism, calorimetry, or body temperature in which tarsiers were the subject of investigation. It was therefore decided to measure their respiratory exchange, compute their respiratory quotient and caloric turnover, and compare them in these respects with other animals.

METHOD

The method employed was the open circuit gravimetric procedure, using a Becker balance of 5 kilograms capacity. Room air, free of carbon dioxide and water vapor, was humified before entering the animal chamber (a dome topped desiccator jar) and check tubes of Drierite (anhydrous calcium sulfate) were interposed beyond the water and carbon dioxide absorbers. Air was circulated through the system for half an hour before the first weighings of each run and the temperature was noted by a thermometer within the chamber. The apparatus was tested with a fasted white rat, which gave the expected respiratory quotient, and two alcohol checks were carried out, each showing an R.Q. of 0.67 when 1.5 grams of absolute alcohol were burned in the chamber. The ventilation rate during animal tests kept the carbon dioxide concentration below 0.6 per cent.

The chamber was carefully screened, so that the animal would not be disturbed, and the room was quiet. When the animals were cautiously looked at they always seemed to be quiet but awake and the greatest movement seen was a slow turning of the head. Since they are wholly nocturnal in habits and showed no alarm on being transferred to the respiration chamber, it is believed that a fairly good state of muscular repose was present although the sitting position was maintained. While some of the tests were done only a few hours after removal of food from the cage, the animal's habit of eating in the early evening probably makes the true time since ingesting food much longer than that given in the table.

TABLE 1.—*Daily respiratory metabolism of tarsius spectrum*

	DATE	WEIGHT IN GRAMS	LENGTH OF TEST IN MIN.	TIME SINCE FEEDING IN HOURS	TEMP. IN °C.	OXYGEN IN LITERS	R.Q.	CAL.
Animal IV, female	Feb. 27	202	109	7	28	2.95	1.00	15.0
	Mar. 2	202	129	13	27	3.15	0.91	15.6
	Nov. 8	208	100	16	29	3.24	0.81	15.6
	Jan. 1	216	100	1	26	3.85	0.83	18.5
	Jan. 1	216	60	3	26	4.05	0.82	19.4
	Feb. 7	224	100	15	25	3.66	0.80	17.7
	Feb. 7	224	115	17	25	4.20	0.79	20.2
Animal V, male	Jan. 13	171	87	14	25	3.34	0.86	16.1
	Jan. 13	171	100	16	25	3.64	0.76	17.5
	Jan. 17	174	90	16	25	4.13	0.81	19.9
	Jan. 17	174	100	18	25	3.63	0.75	17.5

DISCUSSION

The female was sexually mature and probably four or five years old at the time the determinations were made, while the male was immature and about two years old. They have both died since, the female in June 1940 of a severe filarial infestation, and the male, similarly afflicted, was sacrificed a few weeks later. At the time of the metabolic studies their health was good and their weight curves had not started to fall (see Catchpole and Fulton, 1943).

The individuals studied are too few, and the data are too scanty and scattering to permit one to place the tarsiers accurately among other animals in respect to metabolic activity. The total daily calories of the male agrees well with data for rats of the same weight given by Benedict (1938) while the metabolism of the female is about 15 percent lower than that of a rat of equal weight. Bruhn's (1934) observations warrant the tentative assumption of $K = 12$ in the Meeh formula for surface area, $A = KW^{2/3}$. The calculated average calories per square meter per day is 590 for the female and 680 for the male, while Bruhn found 653 as the average of 10 rhesus and mangabey monkeys. Except for the determination on February 27, the respiratory quotients are in the usual range, showing that this species has no unexpected reserves of carbohydrate or fat that it might call upon in the early stages of a period of fasting.

This study was aided by grants from the Fluid Research Funds, Yale University School of Medicine.

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GENERAL NOTES

CARNIVOROUS ACTIVITIES OF BIG BROWN AND PALLID BATS

Blyth (Jour. Asiatic Soc. Bengal, vol. 11, pp. 255–262, 1842) has reported the carnivorous habits acquired by some bats of the genus *Lyoderma*, while Hutton (Proc. Zool. Soc. London, pp. 690–714, 1872) attested to the fact that some large members of the genus *Myotis* of India were found to prey upon smaller bats when confined in the same cage with them. Since then several reports of carnivorous and piscivorous habits of bats have been recounted, but to my knowledge there has been none concerning bats of the United States.

On June 6, 1940, I visited Palomar Mountain in San Diego County, California, and there collected several *Eptesicus fuscus* and *Myotis evotis chrysonotus* from behind the boarded windows of a cabin. I placed one of each species in a sugar sack intending to skin them the following day. The next morning on examining the sack in which the bats had been kept I found that the *Eptesicus* had eaten the entire *Myotis* except for the wings, the tail, and a small patch of skin on the back.

On another occasion, March 15, 1941, I collected eight *Antrozous pallidus pacificus* and two *Tadarida mexicana* from the same crevice beneath a wooden bridge and placed them together in a small cage. Although the two species would hang in separate corners of the cage there was no apparent disharmony between them. No food was available to them but water was at their disposal. On the morning of the fourth day of captivity one of the *Tadarida* was found with its head and neck chewed off to the shoulder region.

On the afternoon of March 28, 1940, two western skinks, *Eumeces skiltonianus*, were brought in to the laboratory. Having no convenient place in which to keep them, I placed them in a small wire cage with two female *Antrozous*. Later on that same afternoon, I found that only one of the skinks remained. It was well hidden and protected in the corner of the cage. The plump and alert condition of one of the bats suggested a possible location of the second skink. Desiring to verify the assumption that the bat had recently partaken of a meal, I prodded the remaining lizard to the center of the cage. As the skink began to move it made a slight rustling sound. The ears of the bat pricked up and seemed to be trying to locate the exact position of this movement. Finally, when both ears seemed to be focused on the source of the sound, the bat loosed its hold and dropped to the bottom of the cage. It immediately pounced on the skink, completely covering it with its outstretched wings and interfemoral membrane. It gave the animal a dozen or more sharp bites from head to tail, the latter dropping off. The struggles of the skink were soon over and it seemed to be well on its way to join its former companion in the stomach of the bat. Beginning at the head, the bat ate the entire lizard in 23 minutes. With bulging sides, the bat returned to the top of the cage and was soon asleep.

Again, in the Spring of 1941, I had several *Antrozous* in captivity. In the cage with the bats I placed a Sonoran desert gecko, *Coleonyx variegatus*, which a student had given to me. At first the bats paid no attention to it, remaining inactive in their inverted position

at the top of the cage. Later when I returned, the gecko was gone but one of the bats appeared to be well filled.

Both of these lizards are known to be nocturnal in their habits. It is also known that *Antrozous* often alight on the ground in pursuit of prey (see Burt, Trans. San Diego Soc. Nat. Hist., vol. 7, p. 397). I have seen this occur twice and have removed the remains of many flightless Jerusalem crickets from beneath the feeding stations of this bat.

One might conclude from this that these bats are not strictly insectivorous in their diet although captivity may have influenced their accepting these various items as a source of food.—Carl H. Engler, *Dept. Zoology, Cornell University, Ithaca, New York.*

THE STATUS OF THE VICUNA IN SOUTHERN PERU, 1940

While collecting mammals for the Museum of Comparative Zoology in 1939–40 with the Gardner Peruvian Expedition, I had an excellent opportunity to observe the number of vicunas living in southern Peru. The hunting of these lovely animals, so prized for their rich fur, has long been prohibited by the Peruvian Government.

It is a pleasure to report that the vicuna is still present in considerable numbers in many of the less accessible regions of the high Andes. They were seen frequently in the country to the north and south of the railroad from Arequipa to Lake Titicaca, as well as along the railroad itself, always at an altitude greater than 12,000 feet. Although occasionally seen within a few hundred yards of native huts, they seemed to prefer uninhabited terrain.

At one rather inaccessible location where they were particularly abundant they were not as wary as might be hoped. A number of herds frequently were visible from our camp at the same time and would drink at a stream only a few hundred yards from our tent. They occurred in groups numbering from 2 to 20, but more than 15 in one herd was unusual. In this region they would allow a man to approach cautiously to a distance of about 200 yards, upon which they would emit a rather prolonged soprano whinny and disappear rapidly over the nearest rise. While it is not possible to give an accurate estimate of the number of vicunas living in any of these regions, some idea of their numbers may be derived from the fact that at the camp near which they were most abundant, more than 50 could be counted easily in a morning.

The most important enemies of the vicuna are the large cats and man. Several large scats were found, probably of puma, containing vicuna remains. In spite of government protection, man continues to take a toll of these animals, petty officials and others who are above the law frequently being the culprits. The incentive for hunting them is usually the luxurious fur, which is of great value, but those who have eaten the flesh add that it is so delicious as to repay one for the slight risk taken in securing it. Robes made of vicuna fur are still bootlegged to tourists in Arequipa. If the purchaser seems aware of the government restrictions, he may be shown a real vicuna robe but told that it is merely alpaca, while the price, of course, remains at the vicuna level.—Oliver P. Pearson, *Biological Laboratory, Harvard University, Cambridge, Mass.*

NOTES ON THE BACHMAN SHREW

Having been deeply interested in article by Dr. William L. Engels of the University of North Carolina on Bachman's Shrew (*Sorex longirostris longirostris*) in the November 1941 issue of the Journal of Mammalogy, I am giving below an account of my experience with this rare little mammal. Special emphasis is placed on the terrain in which specimens were taken.

It has been my good fortune to capture eight specimens of *Sorex longirostris longirostris* in the last 3 years, all of which were submitted to the late Mr. Arthur H. Howell, or to Dr. H. H. T. Jackson, for determination of species and subspecies.

The first four specimens were taken in central Amelia County, Virginia, about 40 miles west and a little south of Richmond. The last four were taken in the Seward Forest area

in southeastern Brunswick County, Va., 8 to 10 miles north of the Virginia-North Carolina state line.

Specimen no. 222 was taken Nov. 3, 1938, in a heavy growth of "sedge grass" at the upper end of a small sphagnum bog, in an old field, about 150 yards from the nearest woods. There were a few small pine trees (*Pinus virginiana*) scattered through the field.

Specimen no. 389, male, was caught March 28, 1940, at the mouth of a pine mouse (*Pitymys*) burrow, near the base of the bank of an old mill race, in good sized second growth mixed woods. The old earth bank was covered with a moderate growth of prostrate honeysuckle (*Lonicera japonica*). The location is about 50 yards from Nibb's Creek, but there is a pool of shallow water in the bottom of the old mill race.

Specimens nos. 394, female, and 395, male, were taken the same night, April 1, 1940, in traps set about 15 feet apart, in a dense growth of prostrate honeysuckle, in a little swale, at the lower border of an old field about 75 yards from the nearest woods. This woods is a scattering second growth of *Pinus echinata*.

Specimen no. 451, female, was taken Nov. 22, 1940, on the steep slope of a rocky bluff south of Rattlesnake Creek, in southeastern Brunswick County, Va. This bluff is covered with large oak and beech trees with considerable undergrowth of witch hazel (*Hamamelis virginiana*), beaked hazelnut (*Corylus rostrata*) (both very unusual in this section), several species of *Vaccininm*, and a sparse growth of shade enduring herbaceous plants. The trap in which it was caught was set at a small hole under a large rock about one third of the way from the waters edge in a bayou of Rattlesnake Creek to the top of the bluff.

Specimen no. 479, female, was taken at the water's edge of a shallow, but permanent pond, surrounded by a good stand of loblolly pines (*Pinus taeda*). The border of the pond carries a dense growth of tall sedges and grasses and in the edge of the water are many plants of fetter bush (*Leucothoe racemosa*) and buttonbush (*Cephalanthus occidentalis*).

Specimens nos. 524 and 525, both females, were taken the same night, Jan. 3, 1941, in traps set about 125 yards apart, in tall, dense sedges and grasses at the former water line of an old mill pond that was drained about two years ago. The nearest water is the small creek that flows through the center of the former pond bed, about 100 yards from the traps.

To summarize, seven of the eight shrews were caught in dense cover, either prostrate honeysuckle or tall sedges and grasses. Four were taken within 40 feet of water. Only three were taken in woods.—JOHN B. LEWIS, *Seward Forest, Triplett, Virginia*.

AN APPARENT MUSTELID TRAIT

Doubtless every naturalist is interested in the question of wildlife mortality on the highways and has speculated about its effects and the reasons why some animals are killed oftener than others. For a long time I have paid particular attention to the latter point, but without keeping any formal record of the carcasses encountered.

I have driven a car regularly for more than 30 years and have done my share of night driving. It has been my experience that on the rural highways one sees far more living domestic cats than any other carnivore, yet it is but seldom that one notes a dead cat away from the towns. In most cases there is eye-shine well ahead of the car and then the dim form of a cat turning leisurely into the brush. It is my impression that in such situations there are a dozen or more dead skunks, in good skunk territory, for every dead cat. Yet I have seen live skunks infrequently on the roads. I do not recall observing more than one skunk well ahead of the car and I have never knowingly hit one. On three or four occasions, however, a dark form has darted across the road when I was too close to note more than the beginning of its transit. I imagine that this is the general experience, and that most skunk fatalities occur without the knowledge of the driver. The impression gained is that when a skunk wishes to cross the road at night it tends to loiter at the margin until an approaching car incites it, not to shrink back into hiding, but to dash, at the last moment, for fancied safety on the other side.

I recall seeing four weasels cross the road and but one made the trip safely. One was the victim of a car that approached me, but I did not observe the beginning of the episode.

Another darted across when I was almost upon it. I slowed the car, to allow ample time, but he evidently became confused and paid the penalty. The fourth (*Mustela c. cicognanii*) crossed hurriedly from my right and almost reached the far edge of the road, only to whirl and dart back directly beneath my front wheel.

The only other mustelid that I have seen cross the road was a badger, at surprising speed, when I was almost upon it.

To me all this is most interesting. Skunks usually have little concern for danger and might be expected to saunter along and across the highway. Instead they cross apparently with maximum celerity and what they doubtless consider extreme circumspection. Seemingly, however, an unfortunate trait, shared with weasels, is that they delay action until the stimulus of an approaching car causes a reflex that operates too late for the survival of a very large proportion of individuals. This trait is probably akin to that which urges some antelopes to race with, and to cross ahead of, anything travelling parallel to their course, even when the last of the herd does not have time to do so safely. Whether skunks are subject to the same sort of panic that causes some weasels, after really having gained safety, to retrace their steps into disaster, I am unable to say.—A. Brazier Howell, *Department of Anatomy, Johns Hopkins Medical School, Baltimore, Maryland.*

A POCKET GOPHER (GEOMYS LUTESCENS) TRAVELS BACKWARD

On the night of August 8, 1941, I was driving along a sandhill trail on the Valentine National Wildlife Refuge 35 miles southwest of Valentine, Nebraska. The trail consisted of two well-worn car tracks that had developed into groove-like ruts about six inches deep, with grass growing between them. As I rounded a slight curve, a pocket gopher (*Geomys lutescens* Merriam) was seen approaching along one of the ruts. The sudden appearance of the bright lights of the car surprised the gopher. It stopped, raised its head in a characteristic gopher pose, and suddenly ran backward down the trail from the car for about 15 feet. Its manner of running in reverse was smooth and efficient, and, so far as I could estimate, was as rapid as its ability to run forward.

The writer concludes, to his own satisfaction at least, that *Geomys lutescens* is capable of traveling along its subterranean runways in reverse as well as forward. Its skill in traveling backward appears well-developed.—Ward M. Sharp, *Fish and Wildlife Service, Valentine National Wildlife Refuge, Valentine, Nebraska.*

WEASEL VERSUS SQUIRREL IN SEQUOIA NATIONAL PARK

The occupants of the governmental sleeping quarters at Lodgepole Camp on the Marble Fork of the Kaweah River in Sequoia National Park were aroused about 6:30 on the morning of August 15, 1941, by hearing the alarm notes of many small rodents—chipmunks (*Eutamias* spp.), chickarees (*Sciurus douglasii*), and golden mantled ground squirrels (*Citellus lateralis*), the majority of which were perched on rocks near the road that runs through the camp. Little attention was paid to the rodents' alarm, because it was believed to be merely a passing hawk, until two animals were seen running rapidly in a zig-zag course on the oiled road about 75 feet from the line of rangers' houses.

A golden mantled ground squirrel was attempting to avoid the lunges of a mountain weasel (*Mustela frenata*) and in so doing was running frantically down the center of the road. The pursuing weasel managed to catch up and succeeded in getting a hold on the back of the neck of the squirrel three separate times, but in each case it was thrown off by the frightened rodent. The squirrel shrieked incessantly as both mammals ran toward the Marble Fork, about 100 feet distant. When within six feet of the river's edge, the weasel succeeded in grasping the back of the squirrel's neck in its jaws. The frenzied rodent twisted and turned its body, rolling over and over in an attempt, finally successful, to rid itself of the weasel. After freeing itself, the squirrel rushed blindly into the river and the carnivore, in the heat of the chase, plunged into the water behind it. When approximately four feet from the bank in a shallow pool about six inches deep, each animal seemed to forget the other in an attempt to reach shore.

a small water-worn cavern, carrying an object suggesting a fish about 18 or 20 inches in length.

With eight power binoculars, I very clearly and definitely recognized the object as a newly born sea lion calf carried by the nape. The small head, large fore flippers and bright red navel cord were the most pronounced identification. At this moment three western gulls (*Larus occidentalis wymani*), perched nearby, arrived in a group and immediately began trailing and plucking the navel cord. Three defiant efforts in defense of the newly born calf were staged at approximately fifteen-foot intervals, and the cow's progress was slow. The calf was released and lay motionless during each protective skirmish. It was clearly evident the cow sea lion was greatly perturbed by the behavior and persistence of the three snipping gulls. There was no hesitation in the headlong plunge on reaching the surf, other than clasping the calf between her fore flippers as both disappeared in the surf and were not seen again. The overall distance traveled from cavern to surf I judged was approximately 50 feet. The time consumed was 12 minutes.—CLARENCE W. FRY, *Sequoia National Park, California.*

SOME MAMMALIAN ECTOPARASITES FROM WEST VIRGINIA

The following ectoparasites and their hosts were collected in the northcentral, northeastern, and southeastern counties of West Virginia. All specimens were taken during 1940–41:

HOST	PARASITE
Myotis l. lucifugus	*Cimex adjunctus*
Myotis l. lucifugus	*Myodopsylla insignis*
Sciurus carolinensis leucotis	*Orchopeas wickhami*
Peromyscus leucopus noveboracensis	*Cuterebra sp.*
Peromyscus leucopus noveboracensis	*Orchopeas leucopus*
Peromyscus leucopus noveboracensis	*Peromyscopsylla hesperomys*
Peromyscus leucopus noveboracensis	*Atricholaelops glasgowi*
Microtus p. pennsylvanicus	*Polyplax spinulosa*
Microtus p. pennsylvanicus	*Dermacentor variabilis*
Clethrionomys gapperi carolinensis	*Orchopeas leucopus*
Clethrionomys gapperi carolinensis	*Ixodes* sp.
Neotoma magister	*Orchopeas sexdentatus pennsylvanicus*
Neotoma magister	*Epitedia wenmanni*

Leptinus testaceous Mueller has been taken from *Clethrionomys gapperi carolinensis*, both in Hardy and Pocahontas counties, although it has not definitely been determined whether it is a parasite or merely a guest. On at least three occasions it was found on the rodent long after the death of the latter.

Thanks are due Dr. H. E. Ewing, Dr. J. C. Bequaert, Mr. H. S. Fuller, and Prof. Irving Fox, who kindly identified the parasitic specimens.—L. WAYNE WILSON, *Moorefield, West Virginia.*

SPEED OF PREDATOR AND PREY

The ability of coyotes to overtake and drag down healthy adult mule deer is a subject upon which naturalists sometimes disagree. During the fall of 1941, the writer had opportunity to make three observations on the running speed of these two animals, which are of interest in this connection.

On the night of August 22 the writer drove upon a two-point buck mule deer in a road, in Unit 1 of the Malheur National Wildlife Refuge, lined on both sides by a heavy stand of willows. The buck ran in front of the car for nearly 0.3 mile before it found a suitable gap in the willows for escape. The maximum speed attained was 35 miles an hour, which it held for approximately 0.2 mile before slowing slightly. The gait was a jerky gallop more

like that of the antelope than the typical bounding method of running of the mule deer when not pressed so closely. The author, in company with Messrs. J. C. Salyer, J. C. Scharff, and P. T. Kreager, on October 25, 1941, recorded the running speed of a doe and two fawns as 28 miles an hour for a distance of 0.3 mile. These animals also ran with a jerky gallop and discarded their usual bounding tactics except at the start of the race and when they veered to one side and slowed down. The buck did his sprinting along a hard gravel roadway that contained some fair-sized gravel, whereas the doe and fawns ran on fairly soft ground next to a roadway.

On the morning of October 16, 1941, a coyote was clocked in Unit 3 of the Malheur Refuge at 29 miles an hour for 0.1 mile before escaping to a field, at one side of the road. It was close pressed and was running at its top speed on the dirt and turf at the side of the road. This animal could have overtaken the doe and fawns that were timed October 25, but would have had to tire the sprinting buck of August 22 somewhat and perhaps work on it in relays with a partner before overtaking it.

All of the above animals appeared healthy and in good condition.—CLARENCE A. SOOTER, *U. S. Fish and Wildlife Service, Washington, D. C.*

CALIFORNIA WINTER RECORDS OF MACROTUS CALIFORNICUS BAIRD

Although the one time belief that the California leaf-nosed bat, *Macrotus californicus* Baird, does not occur in California during the winter months has been disproven, records of the continuous occupation of this species throughout the winter season in any one locality are few.

During the winter of 1940–41, the writer had occasion to make several checks on the wintering activity of this species. Mines and powder magazines near Laguna and Imperial Dams, Imperial County, California, were visited on September 24, October 5, and December 5, 1940, and on January 9, 1941. That on each of these visits numbers of bats of this species were observed in the tunnels should serve to substantiate the already existing evidence that the mammal under consideration winters north of the Mexican boundary.—LEE W. ARNOLD, *Yuma, Arizona.*

SYNAPTOMYS COOPERI STONEI FROM THE EASTERN SHORE OF MARYLAND

On November 29, 1941 the writer, acting on the information of Mr. Kenneth Wilson of the Maryland State Game and Inland Fish Commission that he had found what he believed to be a *Synaptomys* skull in pellets of the Barred Owl collected along the Pocomoke River, Worcester County, Maryland, accompanied Mr. Wilson to the region. After some scouting among the cypress swamps in the region we found what appeared to be a suitable habitat for *Synaptomys* in deep sphagnum about 6 miles southwest of Snow Hill and set out a line of traps. On the following morning, November 30, an adult female *Synaptomys cooperi stonei* was found in one of the traps.

This I believe to be the first record of this rodent for the Delmarva Peninsula region. A. Brazier Howell (N. A. Fauna, 1927, p. 16) mentions specimens taken at Hyattsville and in Prince George County, Maryland. These localities are 75 to 100 miles northwest of the Pocomoke, and approximately the same distance from May's Landing, New Jersey, the type locality of the race. Since Lake Drummond, the type locality of *Synaptomys cooperi helaletes*, is only slightly more than this distance to the south, I was interested in measuring the skull to ascertain whether it might prove intermediate between the two races, but such did not prove to be the case. All characters are distinctly those of *stonei*.

Of considerable interest at this date is the fact that this specimen was apparently nursing young, as evidenced by the active condition of the mammary glands.—EARL L. POOLE, *Reading Public Museum, Reading, Penna.*

THE RICE RAT, ORYZOMYS PALUSTRIS PALUSTRIS, IN DELAWARE

Reports came in the autumn of 1940 to the Division of Wildlife Research, U. S. Fish and Wildlife Service, that considerable damage was being done to muskrat pelts after the

muskrats were trapped and allowed to stay in the traps for any length of time on the Bombay Hook Wildlife Refuge, Smyrna, Delaware. To determine the cause of this damage, it was suggested by the Research Division that resort be made to trapping. About December 15, 1941, four rice rats were trapped on or near the refuge which were received on January 1, 1942, at the U. S. Fish and Wildlife Service, Washington, D. C., from John F. Herholdt, Refuge Manager. These rats, known locally as "Norwegians," proved upon examination to be rice rats, *Oryzomys palustris palustris*. The specimens are deposited in the Biological Surveys collection.

Bachman (Audubon, J. J., and Bachman, John, Quadr. North Amer., vol. 3, p. 215, 1854) who studied the habits of *Oryzomys palustris*, records that those kept in captivity "fed on grains of various kinds, but always gave the preference to small pieces of meat." E. A. Goldman stated in his revision of the genus *Oryzomys* (North American Fauna no. 43, p. 23, September 23, 1918), in reference to the geographic distribution of *O. p. palustris*, "not yet known from Delaware . . . but doubtless occurs there." Witmer Stone (Mammals of New Jersey, Report of New Jersey State Museum, p. 74, 1907) records specimens taken near Salem, Cohansey Creek, and Greenwich. These last two localities are almost directly across the Delaware River from Bombay Hook, but as far as I have been able to determine, *Oryzomys* has not been previously recorded from the State of Delaware.—Viola S. Schantz, *U. S. Fish and Wildlife Service, Washington, D. C.*

THE LEMMING MOUSE IN SHENANDOAH MOUNTAINS, VIRGINIA

On October 24, 1941, one female lemming mouse (*Synaptomys cooperi*) containing five embryos was collected at Camp Todd in the North River Refuge, of the George Washington National Forest in the Shenandoah Mountains, Augusta County, Virginia. The specimen was collected in a small marshy area within a forest opening along a small mountain stream. The dominant plants of the area were sedges (*Carex* spp.) and ragwort (*Senecio aureus*). The complete skeleton of this specimen was deposited in the Food Habits Laboratory collection at the Patuxent Research Refuge, Bowie, Maryland.—Robert E. Stewart, *Fish and Wildlife Service, Bowie, Maryland.*

CATERPILLARS AS FOOD OF THE GRAY SQUIRREL

No mammals are more profligate feeders than tree squirrels, these animals disdaining few items for their dietary. Their fondness for insects has occasionally been mentioned, but specific accounts are scarce.

On June 13, 1937, I watched at rather close range, two gray squirrels, *Sciurus carolinensis leucotis*, chipping the loose bark from a large white oak in an industrious search for large gray geometrid caterpillars which they were eating in some numbers and with evident relish. The ground below the oaks was covered with chips of bark, some of them about two inches in diameter, that were loosened or torn from the tree.

On May 30, 1942, I again had the opportunity of watching a gray squirrel tearing away the loose bark of hickory, *Carya ovata*, exposing geometrid caterpillars. The squirrel was making a successful search among the lower branches of the tree, finding and eating more than a dozen of these caterpillars while I watched it. When the squirrel finally took alarm, I collected several of the caterpillars. I am indebted to Dr. W. T. M. Forbes of Cornell University for determining them as the Halfwing Geometer, *Phigalia titea*.—W. J. Hamilton, Jr., *Cornell University, Ithaca, New York.*

REVIEWS

Bole, B. Patterson, Jr., and Moulthrop, Philip N. THE OHIO RECENT MAMMAL COLLECTION IN THE CLEVELAND MUSEUM OF NATURAL HISTORY. Sci. Publs. Cleveland Mus. Nat. Hist., vol. 5, no. 6, pp. 83–181, September 11, 1942. Sixty-four species of Recent (in the geological sense) mammals from Ohio are recorded and if subspecies as well as species be reckoned there are 75 kinds. Seven other species, rice rat, river otter, wolverine, coyote, lynx, bobcat and mountain lion are mentioned but not formally listed. Introduced kinds included are the ferret, house cat, Norway rat, black rat, 2 subspecies of the house mouse and the Ord kangaroo rat. The ring-tailed cat, *Bassariscus astutus*, is recorded and the authors "feel that a form [of it] . . . occurred very sparingly until about 1875." Eleven new names, unless otherwise noted, applicable to mammals of Ohio, are proposed as follows: *Sorex cinereus ohionensis*, *Cryptotis parva elasson*, *Blarina brevicauda kirtlandi*, *B. b. churchi* (North Carolina), *B. b. hooperi* (Vermont), *Tamias striatus rufescens*, *T. s. ohionensis*, *Synaptomys cooperi saturatus*, *Microtus ochrogaster ohionensis*, *Zapus hudsonius brevipes*, and *Z. h. rafinesquei*. The subspecific name *Zapus hudsonius hardyi* Batchelder long out of use is revived and a few new combinations appear, as for example *Microtus ochrogaster minor* (Merriam). A revised classification for all of the kinds of the *ochrogaster* group of *Microtus*, and for the races of *Blarina brevicauda*, several kinds of which do not occur in Ohio, is included.

"It is significant that the 2 commonest species of Ohio mice, the meadow vole [*Microtus pennsylvanicus*] and the deer mouse, and the commonest shrew, the lake states blarina, are the least variable of all Ohio small mammals . . . these three species cover the state at all times in huge, continuous colonies within their respective habitats [exception is made for the vole in the southeastern counties]. All the other species of these two groups become rare or absent in certain parts of the state during their cyclical minima, and their populations become discontinuous. In the rarer forms, the species never attain general distribution even during their maximum populations, and many of these occur in isolated colonies, sometimes widely separated. It is these rarer forms that show the greatest taxonomic variability."

Substantial evidence is presented to show that chipmunks of the genus *Tamias* have 2 annual molts instead of only one as the last reviser of the genus thought.

The above samples of the paper's content show that it contains information of application to an area much more extensive than Ohio itself.

The eleven new names listed above are the result of the authors' attempt to make a careful systematic appraisal of their materials from Ohio. A few kinds were not thus critically studied, for example *Mephitis*, but "The writers, faced with the prospect of early call to military service, therefore hasten to summarize the results of 10 years of research, incomplete for certain species as these may be." This statement perhaps serves to explain the lack of a table of contents, any distribution map, or a summation of the results of systematic study. Regardless of these omissions, mammalogists will be grateful to the authors for their having published, and thus made available to others, the results of their studies at this time. Other zoologists also contemplating joining the armed forces might serve science best by following the example of Bole and Moulthrop in putting manuscripts of their findings in the hands of the printer before leaving for military service.—E. RAYMOND HALL.

Troughton, Ellis. FURRED ANIMALS OF AUSTRALIA. Angus and Robertson Ltd., Sydney, pp. xxvii + 374, 25 colored plates, 8 vo. cloth (14 shillings, 6 pence), 1941. This book, by a thoroughly competent mammalogist, fills a real need because previous works of comprehensive scope on the mammals of Australia, notably Gould's handsome volumes, are unavailable to the average layman and to many zoologists as well. Troughton's book lists each species, gives its distribution, presents a nontechnical comparative description, and records distinctive habits or other noteworthy attributes. The twenty-five colored plates average about 7 figures per plate and are spaced so that illustrations of nearly all subgeneric types are in the

signature of corresponding text. The artist, Neville W. Cayley, the pressman and all others concerned are to be congratulated on the high quality of these small scale illustrations which, as much as any other one feature of the book, make it serve the intended function of providing quickly to the nontechnical reader an adequate notion of the mammal that he seeks to identify or the one that he is reading about.

Subspecies are mentioned, but only briefly. A rough count indicates that 287 species (411 kinds if subspecies are included) of native mammals are treated. By orders these are: monotremes, 2; marsupials, 146; carnivores (the dingo), 1; sirenians, 1; seals, 6; rodents, 82; and bats, 49. The cetaceans are discussed as a group but species are not named or figured. Some zoologists may be surprised to learn that there are only about twice as many kinds of marsupials as of rodents in Australia. The specialist in systematics is referred to "A checklist of the mammals recorded from Australia" previously published by T. Iredale and E. Troughton and the latter therefore omits from the present book technical material thatwould not usefully serve the student of general natural history.

Among the many interesting items of information to be gleaned from the book is the fact that kangaroos were not first made known to the Caucasian peoples as a result of Captain Cook's voyage in 1770, for in 1629 a Dutch captain, Pelsart, observed the Dama or Tammar Wallaby and wrote an account of it. Methods to be employed in identifying ambergris are described. In North Queensland there appears to exist a large striped marsupial cat with a body 2 feet long, which never yet has been named for want of a specimen in any zoological collection. Evidence presented elsewhere in the book suggests that still other new species and well-marked races await the mammalogist who undertakes systematic field work in Australia. Nevertheless, the author admits that no planned, long-range programme of field study of the mammals has been provided for by the Australian government. In view of these circumstances it seems natural that the holotypes of many species would be in collections outside Australia, and it is difficult to more than mildly sympathize with Troughton who repeatedly mentions the unavailability in Australia of the holotypes. True scientific progress would seem to be fostered if Australia made it legally easier for more work to be done by foreign institutions, particularly if she herself has no well organized programme under way. The request for residents to send to the Australian Museum at Sydney, specimens of mammals is repeated several times at different places in the book and it is hoped will aid in bringing a better knowledge of the mammalian fauna.

The predominant theme is tolerance for wild life and at the book's beginning "A Creed for Nature Lovers" inspires confidence in the author's sound outlook on the problem of preserving for future use the biological natural resources of the area of which he writes. It would appear that wanton waste of mammals was common in the past.

Mr. Troughton is to be congratulated upon the happy results of his labors for he has made available in readily usable form information desired by biologists in all parts of the world about the continent which holds greatest interest to mammalogists. Also, in a postwar world his book will provide much of the basic information needed there in Australia to practice sound conservation of the neglected fauna.—E. Raymond Hall.

Ellerman, J. R. The Families and Genera of Living Rodents, with a list of named forms (1758–1936) by **R. W. Hayman** and **G. W. C. Holt.** Volume II. Muridae. British Museum (Natural History), pp. xii + 690, 50 figs. in text, 8vo. cloth (1 pound, 15 shillings), March 21, 1941. This volume comprises an inquiry into the status of all the named genera of Recent Muridae, keys to the subfamilies and genera, and a characterization of each genus with a list of all its named species and subspecies. This, with volume 1, which treats of the 22 other families of the order, is the first work of so comprehensive a scope on the Rodentia. The family Muridae alone contains more than half the supposedly valid genera of rodents. Consequently volume two is restricted to the Muridae, and therefore lacks the controversial material that makes difficult the classification of the rodents into larger systematic categories. Included is a special discussion of the rats of Madagascar and a section on the distribution of the genera and principal species in the geographical regions of the world. In volume 1

(p. 47) the suggestion is made "that a large section of the Muridae evolved in Australia and came into Asia via some islands as Celebes and the Philippines. . . ."

Ellerman lists 12 subfamilies of Muridae. The subfamily name Gymnuromyinae, and so far as I can tell also the name Deomyinae, is newly proposed. The Cricetinae is considered a subfamily, including the "Neotominae." In these 12 subfamilies the author examined and retained 186 genera. He mentions 16 additional genera of which he has seen no specimens, but thinks that at least 6 and perhaps more of these are valid. The 186 genera include about 3600 named forms. The author employs the term "about" for he doubts the validity of certain named kinds, or cites opinions of previous workers who doubted their validity. Some species and subspecies are included *incertae sedis*. Ellerman has perhaps been over-cautious in synonymizing or reducing several named kinds to subspecific or subgeneric rank where he is seemingly convinced that so doing is advisable. On page 643, he lists new names proposed in the second volume as follows: *Micaëlamys* subgen. nov. for *Rattus granti* Wroughton, *Zokor* subgen. nov. for *Myospalax fontanieri* Milne-Edwards, *Rattus tatei* sp. nov., *R. frosti* sp. nov., *R. hellwaldi dollmani* subsp. nov., *Rattus niobe haymani* to replace *Stenomys klossii* Thomas, *Rattus niobe pococki* to replace *Stenomys niobe clarae* Rummler, *Rattus daltoni ingoldbyi* to replace *Myomys daltoni saturatus* Ingoldby, *Mus musculus* (?) *mohri* to replace *M. mystacinus* Mohr, *Microtus mordax halli* to replace *M. m. angustus* Hall, and *Microtus socialis binominatus* to replace *M. s. satunini* Ognev.

Within a subfamily, the author attempts to arrange the genera in natural groups, and within each group in order of increasing specialization, as based on the view of Hinton and others that complexity of cheek teeth is a primitive character in the family. The Murinae is the largest subfamily, with no less than 71 genera and 1392 species and subspecies. For the genus *Rattus* alone, 547 kinds are listed as valid. The author admits that he has given less attention to the American Cricetinae than to any other group. This is probably because he feels that North American genera have been sufficiently reviewed by American workers, because of the difficulties arising from the numerous names loosely applied to little known South American forms, and because the Cricetinae "is the most difficult group of living Rodents to arrange in any natural order. . . . All American Cricetinae seem to be extremely closely allied, and to have no characters which will constantly separate them from allied genera, in very many instances; even long-standing and well-known genera like *Akodon*, *Peromyscus*, *Oryzomys*, *Phyllotis*, and *Hesperomys* are not in all cases clearly distinguishable, and as each of these may have as many as a dozen closely allied subsidiary genera, the task of arranging these in any natural order is almost impossible." *

Although the terminology employed for the cusps of the cheek teeth is briefly explained, it would have been useful if a labelled diagram had accompanied this, and the explanation would have been more readily found if it had appeared in an introductory or special section, rather than incidentally in the text (p. 74). The list of named forms from Linnaeus' "Tenth Edition" to 1936 is an invaluable and complete part of the book, although a few important nomenclatural changes are not incorporated herein. For example, the names *Neotoma lepida* and *N. stephensi* are not employed as established in 1932 by Goldman in his review of the *Neotoma lepida* group. The authors were obviously aware of this publication for they list forms newly named in it.

The first volume treating of all the rodents exclusive of the Muridae was issued in 1940. A third volume, yet to be published, which is to contain the remaining figures of volume 2 executed by the artist A. J. Engel Terzi, is eagerly awaited. Any shortcomings of volume 2, which indeed are few, will be greatly out-weighed by the vast scope and completeness of the undertaking. Mr. Ellerman and his associates have produced one of the most important books, if not the most important book, that has appeared on mammalogy in the last ten years. —Donald F. Hoffmeister, *Museum of Vertebrate Zoology, Berkeley, California.*

RECENT LITERATURE

(Conducted by Gerrit S. Miller, Jr., Remington Kellogg, and Emma M. Charters)

ACOSTA, JOSEPH DE. Historia natural y moral de las Indias, en que se tratan las cosas notables del cielo, y elementos, metales, plantas y animales dellas: y los ritos, y ceremonias, leyes y gobierno, y guerras de los Indios. Fondo de Cultura Economica, Mexico, D. F., pp. lxxxv + 638. 1940. (Mexican edition prepared by Edmundo O'Gorman, of Acosta's work originally published in 1589. Mammals and birds: pp. 317–343, chapters 33–42 of Book 4.)

ALBANESE, ANTHONY A., and WILHELM BUSCHKE. On cataract and certain other manifestations of tryptophane deficiency in rats. Science, Lancaster, n. s., vol. 95, no. 2475, pp. 584–586. June 5, 1942.

ALCORN, J. R. Food of the barn owl at Soda Lake, Nevada. Condor, Berkeley, vol. 44, no. 3, pp. 128–129. May 15, 1942. (Includes 5 species of rodents.)

ALDEN, ROLAND H. Aspects of the egg-ovary-oviduct relationship in the albino rat. Jour. Exper. Zool., Philadelphia, vol. 90, no. 2, pp. 159–181, pls. 3. July 6, 1942.

——— The periovarial sac in the albino rat. Anat. Record, Philadelphia, vol. 83, no. 3, pp. 421–435, fig. 1, pl. 1. July 25, 1942.

ANDERSON, ALBERT. The "black killer". Conservation Volunteer, St. Paul, vol. 4, no. 21, p. 40. June, 1942. (Wild "wolf dogs" killing deer.)

ANGULO, A. W. The development of fetal behavior in the albino rat and its correlation with the development of the nervous system. (Summary). Proc. 8th Amer. Sci. Congr., Washington, D. C., vol. 3, pp. 19–20. August 3, 1942.

ANONYMOUS. Young of zoo animals on display. News Bull. Staten Island Zool. Soc., New York, vol. 9, no. 3, p. 4, illus. May, 1942. (Photographs of mothers and young of gray and rhesus monkeys.)

——— New mammals on exhibition. News Bull. Staten Island Zool. Soc., New York, vol. 9, no. 3, p. 3, illus. May 1942. (Photograph of jaguar.)

——— Fur animal conservation and restoration from the 1941 annual report of the Director of the Fish and Wildlife Service to the Sec'y of the Interior. Amer. Fur Breeder, Duluth, vol. 14, no. 11, pp. 22–24. May, 1942.

——— South Dakota's jack rabbit business. Amer. Fur Breeder, Duluth, vol. 14, no. 11, p. 24. May, 1942.

——— Sea-lions may be food for fur animals on land. Science News Letter, Washington, D. C., vol. 41, no. 19, p. 296. May 9, 1942.

——— Live mouse found on airliner from Puerto Rico. Science News Letter, Washington, D. C., vol. 41, no. 21, p. 335. May 23, 1942.

——— Birth of porcupine is rare blessed event. Science News Letter, Washington, D. C., vol. 41, no. 22, p. 345. May 30, 1942.

——— Panda up a tree. Animal Kingdom, New York, vol. 45, no. 3, p. 79, illus. May-June, 1942. (Giant panda in New York Zoological Park.)

——— Rare mule deer. Conservation Volunteer, St. Paul, vol. 4, no. 20, p. 49. May, 1942. (First record for Minnesota since 1887.)

——— Wildlife review no. 34. U. S. Dept. Interior, Fish and Wildlife Service, Washington, D. C., 68 pp. (mimeog.). May, 1942. (Citations and brief abstracts of current literature dealing with wildlife management.)

——— The foxes. Living Museum, Springfield, vol. 4, no. 2, pp. 9–10, illus. June, 1942. (Habitat group of red foxes.)

——— Twilight for the rhinoceros. St. Louis Zoo, vol. 13, no. 2, p. 2. June, 1942.

——— They live in Madagascar. Fauna, Philadelphia, vol. 4, no. 2, p. 59, illus. June, 1942. (Madagascar mammals.)

——— Rehabilitating the pronghorn. Wyoming Wild Life, Cheyenne, vol. 7, no. 6, pp. 1–3, 17, illus. June, 1942.

——— Rats are costly pests and a danger to health. Science News Letter, Washington, D. C., vol. 41, no. 24, p. 374. June 13, 1942.

——— Heat called cause of wavy fur in muskrats. Science News Letter, Washington, D. C., vol. 42, no. 3, p. 41. July 18, 1942.

——— Oxen of the ice age. Living Museum, Springfield, vol. 4, no. 4, p. 27. August, 1942. (Muskox.)

——— Albinism in the Virginia deer. Jour. Heredity, Washington, D. C., vol. 33, no. 8, pp. 274, 284, fig. 1. August, 1942.

——— Public Health Service fighting plague in rodents. Concern felt over reports of large numbers of Norway rats in plains states, although no germs found. Science News Letter, Washington, D. C., vol. 42, no. 6, p. 86. August 8, 1942.

——— Wicked wildcat reported at large in Florida. Science News Letter, Washington, D. C., vol. 42, no. 7, p. 100. August 15, 1942. (Jaguarundi reported in northern Florida.)

——— The black death is here. Time, the Weekly Newsmagazine, vol. 40, no. 8, pp. 52, 54, illus. August 24, 1942. (Bubonic plague in wild rodents of western United States.)

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COMMENTS AND NEWS

CANCELLATION OF ANNUAL MEETING FOR 1943

In accordance with requests from several federal agencies that national meetings of all societies be postponed if possible, the Twenty-fifth Annual Meeting of the Society will not be held in 1943, as was announced in number 4 of volume 23 of the Journal of Mammalogy. The annual report of the Treasurer and of the Corresponding Secretary will appear in the May issue of the Journal.

STUDY OF CYCLES

To stimulate interest in the study of cycles in the fields of natural sciences, the Foundation for the Study of Cycles proposes to present a medal to the person making the most valuable contribution to any line of cyclic research during 1943. Honorable mention for outstanding work along such lines in fields other than that of the winner of the medal also will be made.

Scientific Societies are asked to appoint advisors to work with the judges—Dr. C. C. Abbott, Smithsonian Institution; Professor W. Edwards, McGill University; Professor W. Mitchell, Columbia University; Dr. H. E. Anthony, American Museum of Natural History; and E. Huntington, Yale University. Dr. W. H. Burt, Ann Arbor, Michigan, has been appointed Advisor for the American Society of Mammalogists. Those conducting research in mammalian cycles are urged to contact Dr. Burt.

ACTUAL DATES OF PUBLICATION

Due to circumstances beyond our control, the JOURNAL OF MAMMALOGY may not appear on schedule. The publication dates for volume 23 were:

Number 1 (February)	February 16, 1942
Number 2 (May)	June 3, 1942
Number 3 (August)	August 13, 1942
Number 4 (November)	December 30, 1942

These dates supersede those appearing in vol. 23, no. 4.